TECHNICAL REPORT NO. 501

A FINITE DIFFERENCE METHOD SOLUTION OF NON-SIMILAR, EQUILIBRIUM AND NON-EQUILIBRIUM AIR, BOUNDARY LAYER EQUATIONS WITH LAMINAR AND TURBULENT VISCOSITY MODELS

PART II: COMPUTER PROGRAM AND SUPPLEMENT

(FINAL REPORT)

By H. E. Gould
L. S. Galowin

February 2, 1965

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SUMMARY

This report describes a program for the numerical solution by an explicit finite difference technique of the momentum, species conservation, and energy equations for an equilibrium or chemically reacting air boundary layer. Laminar and several turbulent viscosity models can be applied through the thickness of the boundary layer. Seven air species are included: O_2, O, N_2, N, NO, NO^+ and e^-.

Laminar and turbulent effects in any of the equations can be selectively controlled by input indicators. The various viscosity models can be applied to the entire thickness of the boundary layer or the boundary layer can be divided into two segments and different viscosity models applied to each segment. Provision has also been made for boundary layer swallowing of new inviscid streamlines. Properties along the inviscid streamline are computed to establish the varying streamwise outer edge conditions.

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I. INTRODUCTION

This program is written in FORTRAN II language for the IBM 7090-4. It solves the non-equilibrium and equilibrium air boundary layer conservation equations for momentum, energy and species mass fractions. These parabolic partial differential equations are solved in the domain defined by the body surface and the inviscid edge of the boundary layer. The technique of solution is an explicit finite difference method. The boundary conditions at the body are specified as input data but those at the inviscid outer edge are not known a priori and are therefore computed as the calculation progresses. Edge conditions are determined from the solution of ordinary differential equations

which yield the velocity and species along an approximate inviscid streamline from the shock to the body station of interest. Initial conditions to start the problem require the distributions of the dependent variables of velocity, total enthalpy, and species mass fractions.

A number of significant capabilities are provided by the program. The multicomponent air species considered are O_2, O, N_2, N, NO, NO^+ and e^-. Laminar and several turbulent viscosity representations may be optionally selected for the diffusional transport terms applied to any of the partial differential equations. The boundary layer thickness can be divided into two segments and different viscosity models applied to each of the segments. Various two-dimensional or axisymmetric body geometrical configurations are possible. Similarly, shock shapes consisting of conical and parabolic segments are acceptable. Input tolerances upon the slope at the outer edge of the enthalpy, velocity or species profiles govern the boundary layer swallowing which results from the growth of the viscous layer into the inviscid flow.

The program described herein is based upon the analysis reported in Part I. The engineering definitions and the preparation of input data for application of the program to given boundary

layer problems are discussed in the Part III manual.

Typical hypersonic reentry body configurations have been investigated. Computer time required for their solution ranges from 3/4 to 4 hours, depending on body length, altitude, free stream velocities and mode of computation.

II. BOUNDARY LAYER EQUATIONS

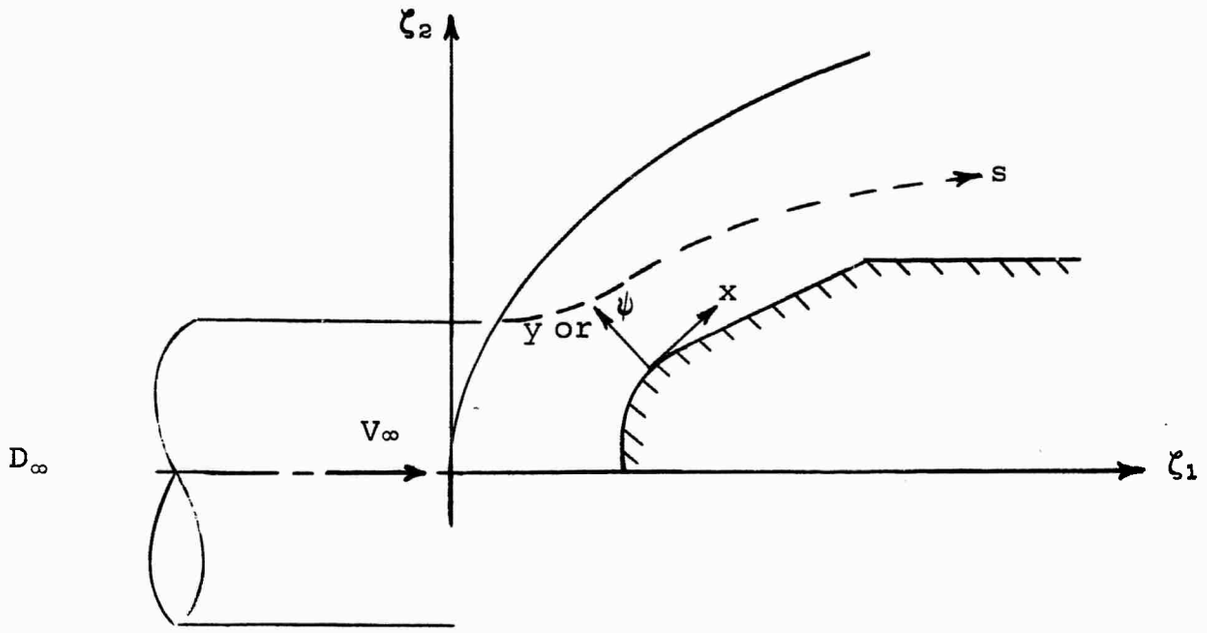
In this section the explicit finite difference method solution of the boundary layer conservation equations is described.

A. Coordinate Systems

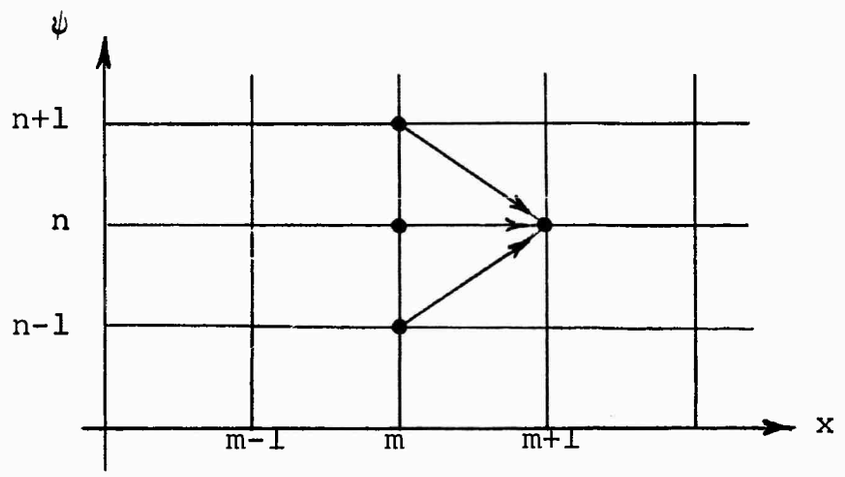
The program continuously calculates in four different coordinate systems. Thus for the permissible body and shock geometry configurations, the following systems shown in the sketch below are defined:

1. Overall - a basic reference system designated as ζ_1, ζ_2. The units of these coordinates are feet.
2. Physical - an x-y system where x, in feet, is along the body and y, in feet, is normal to the body.
3. Body and von Mises stream function - an x-Ψ system in which the finite difference solutions will be solved, where x, in feet, is along the body and Ψ is the transformed normal coordinate and represents the stream function defined by $\Psi = \int_0^y \rho u r^{\epsilon} dy$. For $\epsilon = 1$, Ψ is in slugs/sec; for $\epsilon = 0$, Ψ is in slugs/ft-secs. The sketch below shows the grid in the x-Ψ plane with the paths of the numerical step indicated.

4. Inviscid streamline - a fourth system is a one-dimensional coordinate, s, along the (approximate inviscid) streamline. The origin of this coordinate system is the shock streamtube intersection point.



Coordinate Systems for a Blunt Body



Finite Difference Grid

B. Momentum Equation

1. Analytic form

$$\frac{\partial u}{\partial x} = - \frac{1}{\rho u} \frac{dp}{dx} + r^{\epsilon} \frac{\partial \tau}{d\Psi}$$

$$\tau = \mu \frac{\partial u}{\partial \Psi} \rho u r^{\epsilon}$$

2. Finite difference form

$$u_{m+1,n} = u_{m,n} - \frac{\Delta x}{\rho_{m,n} u_{m,n}} \left(\frac{dp}{dx}\right)_m + \frac{\Delta x}{\Delta \Psi} r_m^{\epsilon} \left(\tau_{m,n+1/2} - \tau_{m,n-1/2}\right)$$

Note: Near the wall a series solution has been assumed since $u \to 0$. The expressions used are:

$$u = a_1 \Psi^{\frac{1}{2}} + b_1 \Psi$$

$$c_i = c_{i_w} + a_{i_2} \Psi^{\frac{1}{2}} + b_{i_2} \Psi$$

$$H = H_w + a_3 \Psi^{\frac{1}{2}} + b_3 \Psi$$

$$\rho u = a_4 \Psi^{\frac{1}{2}} + b_4 \Psi$$

Using the variables evaluated at $\Delta\Psi$ and $2\Delta\Psi$, the a_n's and b_n's are determined. Thus from the series solution the values at $\frac{\Delta\Psi}{2}$ required in the

finite difference solution of the momentum, species and energy equations are then evaluated.

3. The difference in shear stress

$$\Delta\tau = \left[\frac{(\rho u r^{\epsilon})_{m,n+1} + (\rho u r^{\epsilon})_{m,n}}{2}\right]\left[\frac{A_1^L\left(\mu^L_{m,n+1} + \mu^L_{m,n}\right)}{2} + A_1^{T-T}\mu_{m,n+1/2}\right]\left[\frac{u_{m,n+1} - u_{m,n}}{\Delta\Psi}\right]$$

$$- \left[\frac{(\rho u r^{\epsilon})_{m,n} + (\rho u r^{\epsilon})_{m,n-1}}{2}\right]\left[\frac{A_1^L\left(\mu^L_{m,n} + \mu^L_{m,n-1}\right)}{2} + A_1^{T-T}\mu_{m,n-1/2}\right]\left[\frac{u_{m,n} - u_{m,n-1}}{\Delta\Psi}\right]$$

4. Viscosity models

a. Laminar $\mu^L_{m,n} = \dfrac{3.04566 \times 10^{-8} T^{1.5}_{m,n}}{110.333 + T_{m,n}}$

b. Turbulent $\overline{\mu}^T = B_1^T \mu^{T1} + B_2^T \mu^{T2} + B_3^T \mu^{T3} + B_4^T \mu^{T4} + B_5^T \mu^{T5} + B_6^T \mu^{T6} + B_7^T \mu^{T7}$ where the B's are input coefficients and the μ^{Ti} are defined as follows:

i. Law of the wall - dimensional coordinate, y

$$\mu^{T1}_{m,n+1/2} = \left\{ Y_{m,n} + \Delta\Psi \left[\frac{.375}{(\rho u r^{\epsilon})_{m,n}} + \frac{.125}{(\rho u r^{\epsilon})_{m,n+1}} \right] \right\}^2 (FK)^2 \left\{ \frac{\rho_{m,n+1}+\rho_{m,n}}{2} \right\}$$

$$\left\{ \frac{(\rho u r^{\epsilon})_{m,n+1}+(\rho u r^{\epsilon})_{m,n}}{2} \right\} \left| \frac{u_{m,n+1}-u_{m,n}}{\Delta\Psi} \right|$$

$$\mu^{T1}_{m,n-1/2} = \left\{ Y_{m,n} - \Delta\Psi \left[\frac{.125}{(\rho u r^{\epsilon})_{m,n-1}} + \frac{.375}{(\rho u r^{\epsilon})_{m,n}} \right] \right\}^2 (FK)^2 \left\{ \frac{\rho_{m,n}+\rho_{m,n+1}}{2} \right\}$$

$$\left\{ \frac{(\rho u r^{\epsilon})_{m,n}+(\rho u r^{\epsilon})_{m,n-1}}{2} \right\} \left| \frac{u_{m,n}-u_{m,n-1}}{\Delta\Psi} \right|$$

ii. Law of the wake - dimensional coordinate, y_e.

$$\mu^{T2}_{m,n+1/2} = \left\{ \frac{\rho_{m,n+1}+\rho_{m,n}}{2} \right\} \left\{ \frac{K_{m,n+1}+K_{m,n}}{2} \right\} (Y_e u_e)_m$$

$$\mu^{T2}_{m,n-1/2} = \left\{ \frac{\rho_{m,n}+\rho_{m,n-1}}{2} \right\} \left\{ \frac{K_{m,n}+K_{m,n-1}}{2} \right\} (Y_e u_e)_m$$

where K(N) is an input function of Ψ

$$K(N) = a + b\Psi + c\Psi^2$$

iii. Laminar contribution

$$\mu^{T3}_{m,n+1/2} = 1/2 \left\{\mu^{L}_{m,n} + \mu^{L}_{m,n+1}\right\}$$

$$\mu^{T3}_{m,n-1/2} = 1/2 \left\{\mu^{L}_{m,n} + \mu^{L}_{m,n-1}\right\}$$

iv. Eddy viscosity fit - dimensional coordinate, y

$$\mu^{T4}_{m,n+1/2} = \left\{ (Y_e)_m \left[.14 - .08 \left(1 - \frac{Y_{m,n} + \Delta\Psi\left(\frac{.375}{(\rho u r^{\epsilon})_{m,n}} + \frac{.125}{(\rho u r^{\epsilon})_{m,n+1}}\right)}{(Y_e)_m} \right)^2 \right.\right.$$

$$\left.\left. - .06 \left(1 - \frac{Y_{m,n} + \Delta\Psi\left(\frac{.375}{(\rho u r^{\epsilon})_{m,n}} + \frac{.125}{(\rho u r^{\epsilon})_{m,n+1}}\right)}{(Y_e)_m} \right)^4 \right] \right\}^2$$

$$\left\{\frac{\rho_{m,n} + \rho_{m,n+1}}{2}\right\} \left\{\frac{(\rho u r^{\epsilon})_{m,n+1} + (\rho u r^{\epsilon})_{m,n}}{2}\right\} \left|\frac{u_{m,n+1} - u_{m,n}}{\Delta\Psi}\right|$$

$$\mu^{T4}_{m,n-1/2} = \left\{ (Y_e)_m \left[.14 - .08 \left(1 - \frac{Y_{m,n} - \Delta\Psi \left(\frac{.125}{(\rho u r^{\epsilon})_{m,n-1}} + \frac{.375}{(\rho u r^{\epsilon})_{m,n}} \right)}{(Y_e)_m} \right)^2 \right. \right.$$

$$\left. \left. - .06 \left(1 - \frac{Y_{m,n} - \Delta\Psi \left(\frac{.125}{(\rho u r^{\epsilon})_{m,n-1}} + \frac{.375}{(\rho u r^{\epsilon})_{m,n}} \right)}{(Y_e)_m} \right)^4 \right] \right\}^2$$

$$\left\{ \frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right\} \left\{ \frac{(\rho u r^{\epsilon})_{m,n} + (\rho u r^{\epsilon})_{m,n-1}}{2} \right\} \left| \frac{u_{m,n} - u_{m,n-1}}{\Delta\Psi} \right|$$

v. Law of the wall - streamline coordinate, Ψ

$$\mu^{T5}_{m,n+1/2} = \left[\left(\Psi_n + \frac{\Delta\Psi}{2} \right) \left(\frac{FK}{\rho_e u_e r^{\epsilon}} \right)_m \right]^2 \left[\frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right] \left[\frac{(\rho u r^{\epsilon})_{m,n+1} + (\rho u r^{\epsilon})_{m,n}}{2} \right]$$

$$\left| \frac{u_{m,n+1} - u_{m,n}}{\Delta\Psi} \right|$$

$$\mu^{T5}_{m,n-1/2} = \left[\left(\Psi_n - \frac{\Delta\Psi}{2} \right) \left(\frac{FK}{\rho_e u_e r^{\epsilon}} \right)_m \right]^2 \left[\frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right] \left[\frac{(\rho u r^{\epsilon})_{m,n} + (\rho u r^{\epsilon})_{m,n-1}}{2} \right]$$

$$\left| \frac{u_{m,n} - u_{m,n-1}}{\Delta\Psi} \right|$$

vi. Law of the wake - streamline coordinate, Ψ_e

$$\mu^{T6}_{m,n+1/2} = \left(\frac{\rho_{m,n+1}+\rho_{m,n}}{2}\right)\left(\frac{K_{n+1}+K_n}{2}\right)\frac{\Psi_e}{(\rho_e r^\epsilon)_m}$$

$$\mu^{T6}_{m,n-1/2} = \left(\frac{\rho_{m,n}+\rho_{m,n-1}}{2}\right)\left(\frac{K_n+K_{n-1}}{2}\right)\frac{\Psi_e}{(\rho_e r^\epsilon)_m}$$

vii. Eddy viscosity fit - streamline coordinate, Ψ

$$\mu^{T7}_{m,n+1/2} = \left\{\frac{\Psi_e}{(\rho_e u_e r^\epsilon)_m}\left[.14 - .08\left(1-\frac{\Psi_n+\frac{\Delta\Psi}{2}}{\Psi_e}\right)^2 - .06\left(1-\frac{\Psi_n+\frac{\Delta\Psi}{2}}{\Psi_e}\right)^4\right]\right\}^2$$

$$\left\{\frac{\rho_{m,n+1}+\rho_{m,n}}{2}\right\}\left\{\frac{(\rho u r^\epsilon)_{m,n+1}+(\rho u r^\epsilon)_{m,n}}{2}\right\}\left|\frac{u_{m,n+1}-u_{m,n}}{\Delta\Psi}\right|$$

$$\mu^{T7}_{m,n-1/2} = \left\{\frac{\Psi_e}{(\rho_e u_e r^\epsilon)_m}\left[.14 - .08\left(1-\frac{\Psi_n-\frac{\Delta\Psi}{2}}{\Psi_e}\right)^2 - .06\left(1-\frac{\Psi_n-\frac{\Delta\Psi}{2}}{\Psi_e}\right)^4\right]\right\}^2$$

$$\left\{\frac{\rho_{m,n}+\rho_{m,n-1}}{2}\right\}\left\{\frac{(\rho u r^\epsilon)_{m,n}+(\rho u r^\epsilon)_{m,n-1}}{2}\right\}\left|\frac{u_{m,n}-u_{m,n-1}}{\Delta\Psi}\right|$$

5. Boundary layer swallowing and expansion of the boundary layer

An input number ϵ_u is used as a test value for calling a new inviscid streamline and to increment the Ψ grid. Two options are available based upon the value of ϵ_u. If $\epsilon_u = 0$, the streamline test is not made. If ϵ_u is set as any positive number (used as the tolerance), the test

$$\left| \frac{u_{m+1}(L+1) - u_{m+1}(L-1)}{u_{m+1}(L+1)} \right| \leq \epsilon_u$$

is made. If the test fails, a new streamline is computed, or constant edge conditions are carried over. When the incremented expansion of the Ψ grid is called for then set $u_{m+1}(L-J) = \frac{u_m(L-J)}{u_m(L-1)} u_{m+1}(L+2)$, for $J = 2, 3, 4$, and $u_{m+1}(L-1) = u_{m+1}(L+2)$.

6. Boundary conditions

a. Initial distributions - an input velocity profile vs. physical coordinates.

b. Inner value at the wall - $u = 0$.

c. Outer edge - velocity at the outer edge is obtained from the finite difference equation of "B" or the inviscid streamline solution of $u \frac{du}{ds} = - \frac{1}{\rho} \frac{dp}{ds}$ accordingly as the momentum, species

or enthalpy slope tests are satisfied or not (see Subsections II.B.5, II.C.5, II.D.5 for formulation of tests).

d. Inviscid streamlines - two inviscid streamlines external to the boundary layer which represent the locally uniform (assumed) external flow are always computed.

C. Species Equation

1. Analytic form

$$\frac{\partial c_i}{\partial x} = \frac{\dot{w}_i A_2}{\rho u} + r^{\epsilon} \frac{\partial \vartheta}{\partial \Psi}, \qquad i = 1,2...7$$

2. Finite difference form

$$(c_i)_{m+1,n} = (c_i)_{m,n} + \frac{\Delta x (\dot{w}_i)_{m,n} A_2}{(\rho u)_{m,n}} + \frac{\Delta x}{\Delta \Psi} r^{\epsilon}_{m,n} \left[\vartheta_{m,n+1/2} - \vartheta_{m,n-1/2} \right]$$

See Section II.B.2 for note regarding solution near the wall.

3. The species diffusion terms are given by:

$$\Delta\mathcal{J} = 1/2 \left\{ \frac{(\rho u r^{\epsilon})_{m,n+1} + (\rho u r^{\epsilon})_{m,n}}{2} \right\} \left\{ A_3^L \left[\left(\frac{\mu^L D_{ki}^L}{S_c^L D^L} \right)_{m,n+1} + \left(\frac{\mu^L D_{ki}^L}{S_c^L D^L} \right)_{m,n} \right] \right.$$

$$+ A_3^{T\_T} \overline{\mu}_{m,n+1/2} \left[\left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n+1} + \left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n} \right] \left\{ \frac{(C_i)_{m,n+1} - (C_i)_{m,n}}{\Delta\Psi} \right\}$$

$$- 1/2 \left\{ \frac{(\rho u r^{\epsilon})_{m,n} + (\rho u r^{\epsilon})_{m,n-1}}{2} \right\} \left\{ A_3^L \left[\left(\frac{\mu^L}{S_c^L} \frac{D_{ki}^L}{D^L} \right)_{m,n} + \left(\frac{\mu^L}{S_c^L} \frac{D_{ki}^L}{D^L} \right)_{m,n-1} \right] \right.$$

$$\left. + A_3^{T\_T} \overline{\mu}_{m,n-1/2} \left[\left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n} + \left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n-1} \right] \right\} \left\{ \frac{(C_i)_{m,n} - (C_i)_{m,n-1}}{\Delta\Psi} \right\}$$

4. Chemistry production terms

a. Formulation

$$\dot{w}_i(\Psi, x) = \dot{w}_i(T, \rho, C_i), \qquad i = 1, 2 \ldots 7$$

$$\dot{w}_{O_2} = \frac{\rho}{L}\left[- A + \frac{M_{O_2}}{M_{NO}} D \right]$$

$$\dot{w}_{O} = \frac{\rho}{L}\left[A + \frac{M_{O}}{M_{NO}} (C-D-E) - \frac{M_{O}}{M_{NO^+}} F \right]$$

$$\dot{w}_{N2} = - \frac{\rho}{L}\left[B + \frac{M_{N2}}{M_{NO}} E \right]$$

$$\dot{w}_{N} = \frac{\rho}{L}\left[B + \frac{M_{N}}{M_{NO}} (C+D+E) - \frac{M_{N}}{M_{NO^+}} F \right]$$

$$\dot{w}_{NO} = \frac{\rho}{L}\left[-C-D+E-K \right]$$

$$\dot{w}_{NO^+} = \frac{\rho}{L}\left[F+K \right]$$

$$\dot{w}_{e^-} = \frac{\rho}{L} \frac{M_e}{M_{NO^+}}\left[F+K \right]$$

where

$$A = \frac{2L}{M_O}\left[\sum_i \frac{C_i}{M_i} K_{ra}^i \right] \rho \left[\rho_{do} C_{O2} e^{D_{O2}/KT} - \rho C_O^2 \right] 9.6573302 \times 10^{25}$$

$$B = \frac{2L}{M_N}\left[\sum_i \frac{C_i}{M_i} K^i_{rb}\right]\rho\left[\rho_{dN} C_{N2} e^{-D_{N2}/KT} - \rho C_N^2\right] 9.6573302 \times 10^{25}$$

$$C = \frac{LM_{NO}}{M_N M_O}\left[\sum_i \frac{C_i}{M_i}\right] K_{rc}\rho\left[\rho_{dNO} C_{NO} e^{-D_{NO}/KT} - \rho C_N C_O\right] 9.6573302 \times 10^{25}$$

$$D = \frac{LM_{NO}}{M_N M_{O2}} K_{rd}\rho\left[\sigma\, C_{NO} C_O e^{-\frac{D_{NO}-D_{O2}}{KT}} - C_{O2} C_N\right] 3.1076201 \times 10^{23}$$

$$E = \frac{LK_{re}}{M_N}\rho\left[\gamma\, C_{N2} C_O e^{-\frac{D_{N2}-D_{NO}}{KT}} - C_{NO} C_N\right] 3.1076201 \times 10^{23}$$

$$F = \frac{LK_{rf}}{M_e}\rho\left[\bar{K}\, C_O C_N e^{-\frac{I_{NO}-D_{NO}}{KT}} - (C_{NO}^+) C_e\right] 3.1076201 \times 10^{23}$$

$$K = \frac{L}{M_e}\left[\sum_i \frac{C_i}{M_i} K^i_{rk}\right]\rho\left[\rho_{de} C_{NO} e^{-I_{NO}/KT} - \rho (C_{NO}^+) C_e\right] 9.6573302 \times 10^{25}$$

Set

$$ETT\ 228 = 5 + 3\, e^{-228/T} + e^{-327/T}$$

$$ET\ 178 = 1 + e^{-178/T}$$

$$ET\ 2274 = 1 - e^{-2274/T}$$

$$ET\ 2740 = 1 - e^{-2740/T}$$

$$ET\ 3395 = 1 - e^{-3395/T}$$

$$ET\ 1130 = 3 + 2\, e^{-11300/T}$$

Then

$$\sigma_{dO} = \frac{M_O}{2\eta h_p^3} (\pi m_O KT)^{3/2} \left(\frac{4.161}{T}\right) (ET\ 2274) \left(\frac{(ETT\ 228)^2}{ET\ 1130}\right) 3.87871 \times 10^{-11}$$

$$\sigma_{dN} = \frac{8M_N}{\eta h_p^3} (\pi m_N KT)^{3/2} \left(\frac{5.789}{T}\right) (ET\ 3395)\ 3.87871 \times 10^{-11}$$

$$\sigma_{dNO} = \frac{M_O}{\eta h_p^3} (2\pi m_O KT)^{3/2} \left(\frac{M_N}{M_{NO}}\right)^{5/2} \left(\frac{4.906}{T}\right) (ET\ 2740) \left(\frac{ETT\ 228}{ET\ 178}\right) 3.87871 \times 10^{-11}$$

$$\sigma = \left(\frac{M_{O2} M_N}{M_{NO} M_O}\right)^{5/2} \left(\frac{4.906}{4.161}\right) \left(\frac{ET\ 2740}{ET\ 2274}\right) \left(\frac{ET\ 1130}{ETT\ 228\ ET\ 178}\right)$$

$$\gamma = 16 \left(\frac{M_{NO} M_N}{M_{N2} M_O}\right)^{5/2} \left(\frac{5.789}{4.906}\right) \left(\frac{ET\ 3395}{ET\ 2740}\right) \left(\frac{ET\ 178}{ETT\ 228}\right)$$

$$\overline{K} = \left(\frac{(M_{NO^+}) \cdot M_e}{M_N M_O}\right)^{5/2} \left(\frac{T}{5.789}\right) \left(\frac{1}{ET\ 3395\ ETT\ 228}\right)$$

$$\rho_{de} = \frac{M_e (2\pi m_e KT)^{3/2}}{\eta h_p^3} (.4237) \left(\frac{ET\ 2740}{ET\ 3395}\right) \frac{2}{ET\ 178}\ 3.87871 \times 10^{-11}$$

b. Input A_2 = 1 for reacting system

= 0 for frozen system; bypass all $\dot{w}_i$

= - 1 for equilibrium system.

≡ 10 for reacting system with equilibrium at the wall

5. Equilibrium mass action laws

As indicated in II.C.4.b, an input of -1 for A_2, activates the logic for obtaining the species from the following equilibrium relationships:

$$c_{m+1}(O_2) = \frac{908.19\ T^{5/2} \left(\frac{5}{3} e^{-\frac{11391}{T}} + \frac{1}{3} e^{-\frac{18985}{T}}\right) \overline{A}^2 (2.773 \times 10^{-15})}{\rho \left(1 - e^{-\frac{2274}{T}}\right)}$$

$$c_{m+1}(O) = \frac{2237\ T^{3/2}\left(1.6\ e^{-\frac{228}{T}} + .2\ e^{-\frac{326}{T}}\right) e^{-\frac{29501}{T}}\ \bar{A}(1.386 \times 10^{-9})}{\rho}$$

$$c_{m+1}(N_2) = \frac{178.39\ T^{5/2} B^2 (2.428 \times 10^{-15})}{\rho\left(1-e^{-\frac{3395}{T}}\right)}$$

$$c_{m+1}(N) = \frac{1462\ T^{3/2}(3.5)\left(e^{-\frac{27698}{T}} + \frac{3}{2}\ e^{-\frac{41520}{T}}\right) e^{-\frac{56544}{T}}\ \bar{B}(1.214 \times 10^{-9}}{\rho}$$

$$c_{m+1}(NO) = \frac{934.14\ T^{5/2}\left(1-e^{-\frac{178}{T}}\right) e^{-\frac{11063}{T}}\ \overline{AB}(2.6 \times 10^{-15})}{\rho\left(1-e^{-\frac{2740}{T}}\right)}$$

$$c_{m+1}(NO^+) = 233.9 \sqrt{\frac{.1597 \times 10^{-11}\ T\ e^{-\frac{32125}{T}}\ c_{m+1}(O)\ c_{m+1}(N)}{\left(1-e^{-\frac{3395}{T}}\right)\left(1.6\ e^{-\frac{228}{T}} + .2\ e^{-\frac{326}{T}}\right)}}$$

$$c_{m+1}(e^-) = \frac{1}{(233.9)^2}\ c_{m+1}(NO^+)$$

$\bar{A}$ and $\bar{B}$ are obtained from an iteration procedure which is satisfied when two successive values of $\bar{B}$ agree to within $\frac{1}{1000}$ %.

The iteration procedure is initiated with $\bar{B} = 0$ and then the following calculations take place in the sequence shown:

$$BT = \frac{\left(2237\ T^{3/2} B_4\ e^{-\frac{29501}{T}}\right) - \bar{B}\left(934.14\ T^{5/2} E_4\ e^{-\frac{11063}{T}}\right) 10^{-18}}{E_3}$$

$$AC = \frac{(908.19\ T^{5/2}) B_1 \rho (1338.7 \times 10^{-12})}{E_1}$$

$$\bar{A} = \frac{\left(-BT + \sqrt{(BT)^2 + AC}\ E_1\right)}{(908.19\ T^{5/2} B_1)(4 \times 10^{-12})}$$

$$BT = \frac{\left(1461.9\ T^{3/2} B_5\ e^{-\frac{56544}{T}}\right) - \bar{A}\left(934.14\ T^{5/2} E_4\ e^{-\frac{11063}{T}}\right) 10^{-18}}{E_3}$$

$$AC = \frac{(178.39\ T^{5/2}) \rho (5060.8 \times 10^{-12})}{E_2}$$

$$\bar{B} = \frac{\left(-BT + \sqrt{(BT)^2 + AC}\right) E_2}{(178.39\ T^{5/2})(4 \times 10^{-12})}$$

where

$$B_1 = \frac{5}{3} e^{-\frac{11390}{T}} + \frac{1}{3} e^{-\frac{18984}{T}}$$

$$B_4 = 1.6\, e^{-\frac{228}{T}} + .2\, e^{-\frac{326}{T}}$$

$$B_5 = 3.5\, e^{-\frac{27698}{T}} + 1.5\, e^{-\frac{41520}{T}}$$

$$E_1 = 1 - e^{-\frac{2274}{T}}$$

$$E_2 = 1 - e^{-\frac{3395}{T}}$$

$$E_3 = 1 - e^{-\frac{2740}{T}}$$

$$E_4 = 1 - e^{-\frac{178}{T}}$$

6. Boundary layer swallowing and expansion of the boundary layer

An input number ϵ_c is used as a test value for calling a new inviscid streamline and to increment the Ψ grid. Two options are available based upon the value of ϵ_c. If $\epsilon_c = 0$, the streamline test is made. If ϵ_c is set as any positive number (used as the tolerance) the test

$$\left| \frac{c_{m+1,i}(L+1) - c_{m+1,i}(L-1)}{c_{m+1,i}(L+1)} \right| \leq \epsilon_c \qquad i=1,\ldots 7$$

is made. If the test fails, a new streamline is computed, or constant edge conditions are carried over. When the incremented expansion of the Ψ grid is called for then set $c_{m+1}(L-J) = \frac{c_m(L-J)}{c_m(L-1)}\, c_{m+1}(L+2)$, for $J = 2, 3, 4$ and $c_{m+1}(L-1) = c_{m+1}(L+2)$.

7. Boundary conditions

   a. Initial - $C_i(y)$ profiles are input for all species except N_2 and e^-, which are computed from:

$$c_{e^-}(N) = \frac{M_{e^-}}{M_{NO^+}}\, C(NO^+)$$

$$c_{N_2}(N) = 1 - \Sigma\, C_i \qquad i \neq N_2$$

   b. Wall - $c_{m+1}(I) = C_1(I) + C_2(I)\frac{x}{Rn} + C_3(I)\left(\frac{x}{Rn}\right)^2 + C_4(I)\left(\frac{x}{Rn}\right)^3 + C_5(I)\left(\frac{x}{Rn}\right)^4$ where the C_1 through C_5 are input for each specie except e^-.

c. Outer edge - Species at the outer edge are obtained from the finite difference equation in Subsection II.C.2. or the inviscid solution of $u \frac{dc_i}{ds} = \frac{\dot{w}_i}{\rho}$ accordingly as the momentum, species or enthalpy slope tests are satisfied or not (see Subsections II.B.5, II.C.5., II.D.5. for formulation of tests).

d. Along the two external inviscid streamlines the species are obtained from the inviscid equation.

D. Energy Equation

1. Analytic form

$$\frac{\partial H}{\partial x} = r^{\epsilon} \frac{\partial}{\partial \Psi} (\mathcal{E}^H + \mathcal{E}^C)$$

2. Finite difference form

$$H_{m+1,n} = H_{m,n} + r_m^{\epsilon} \frac{\Delta x}{\Delta \Psi} (\mathcal{E}^H_{m,n+1/2} - \mathcal{E}^H_{m,n-1/2}) + r_m^{\epsilon} \frac{\Delta x}{\Delta \Psi} (\mathcal{E}^C_{m,n+1/2} - \mathcal{E}^C_{m,n-1/2})$$

See Section II.B.2. for note regarding solution near the wall.

3. The difference of enthalpy-kinetic energy terms $\mathcal{E}^H$ is given by:

N = 2

$$UAVG1 = \frac{r^{\epsilon}}{\Delta\Psi}\left[\rho_{1/2}u_{1/2}^2\left(\frac{du}{d\Psi}\right)_{1/2} + \rho_2 u_2^2\,\frac{(u_2+u_3)}{2} - u_{1/2}\right]$$

$$UAVG2 = \frac{r^{\epsilon}}{2\Delta\Psi}\left[(\rho_3 u_3^2+\rho_2 u_2^2)(u_3-u_2) + \rho_2 u_2^2(u_2+u_3-2u_{1/2})\right]$$

$$SUMHL = 2\sum_i h_{i_{1/2}}\left(\frac{D_{ki}}{D_2^L} + \frac{D_{ki}}{D_1^L}\right)\left(\frac{dC_i}{d\Psi}\right)_{1/2}$$

$$SUMHT = 2\sum_i h_{i_{1/2}}\left(\frac{D_{ki}}{D_2^T} + \frac{D_{ki}}{D_1^T}\right)\left(\frac{dC_i}{d\Psi}\right)_{1/2}$$

$$RURN = 2(\rho u)_{1/2}\, r^{\epsilon}$$

$$PARTH2 = \frac{1}{4}(RURN)\left[A_4^L\mu_{1/2}^L\left(\frac{1}{P_{r_2}^L} + \frac{1}{P_{r_1}^L}\right) + 2A_4^T\left(\frac{\mu_{3/2}^T}{P_{r_1}^T}\right)\right]\left(\frac{dH}{d\Psi}\right)_{1/2}$$

$$+\left[A_4^L(\mu_2^L+\mu_{1/2}^L\left(1-\frac{1}{P_{r_2}^L}\right)\frac{A_4^T}{2}\mu_{3/2}^T\left(1-\frac{1}{P_{r_2}^T}\right)\right] UAVG1$$

$$PARTC2 = \frac{1}{8}\left[2-\frac{1}{L_{e_2}^L}-\frac{1}{L_{e_1}^L}\right]\left[\frac{1}{S_{c_2}^L}+\frac{1}{S_{c_1}^L}\right](RURN)\frac{A_5^L}{4}\mu_{1/2}^L(SUMHL) +$$

$$\frac{1}{8}\left[2-\frac{1}{L_{e_2}^T}-\frac{1}{L_{e_1}^T}\right]\left[\frac{1}{S_{c_2}^T}+\frac{1}{S_{c_1}^T}\right](RURN)\frac{A_3^T}{4}\mu_{1/2}^T(SUMHT)$$

N > 2

$$UAVG1 = \frac{r^{\epsilon}}{2\Delta\Psi}\left[\rho_n u_n^2 (u_{n+1}-u_{n-1}) + (\rho_n u_n^2 + \rho_{n-1} u_{n-1}^2)(u_n - u_{n-1})\right]$$

$$UAVG2 = \frac{r^{\epsilon}}{2\Delta\Psi}\left[\rho_n u_n^2 (u_{n+1}-u_{n-1}) + (\rho_{n+1} u_{n+1}^2 + \rho_n u_n^2)(u_{n+1} - u_n)\right]$$

$$SUMHL = \sum_i (h_{i_n} + h_{i_{n-1}}) \left(\frac{D_{ki}}{D_n^L} + \frac{D_{ki}}{D_{n-1}^L}\right)\left(\frac{dc_i}{d\Psi}\right)$$

$$SUMHT = \sum_i (h_{i_n} + h_{i_{n-1}}) \left(\frac{D_{ki}}{D_n^T} + \frac{D_{ki}}{D_{n-1}^T}\right)\left(\frac{dc_i}{d\Psi}\right)$$

$$RURN = r^{\epsilon}(\rho_n u_n + \rho_{n-1} u_{n-1})$$

$$PARTH2 = \frac{1}{4}(RURN)\left[A_4^L\left(\frac{\mu_n^L}{P_{r_n}^L} + \frac{\mu_{n-1}^L}{P_{r_{n-1}}^L}\right) + A_4^T\left(\frac{\mu_{n-\frac{1}{2}}^T}{P_{r_{n-1}}^T}\right)\right]\frac{dH}{d\Psi} +$$

$$\left[\frac{A_4^L}{4}(\mu_{n-1}^L)\left(1 - \frac{1}{P_{r_{n-1}}^L}\right) + 3\mu_n^L\left(1 - \frac{1}{P_{r_n}^L}\right) + A_4^T \mu_{n-\frac{1}{2}}^T\right.$$

$$\left.\left(1 - \frac{1}{P_{r_n}^T}\right)\right] UAVG1$$

$$\text{PARTC2} = \frac{1}{16}\left(2- \frac{1}{L^L_{e_n}} - \frac{1}{L^L_{e_{n-1}}}\right)\left(\frac{1}{S^L_{c_n}} + \frac{1}{S^L_{c_{n-1}}}\right)(\text{RURN})$$

$$\frac{A^L_5}{4}\,(\mu^L_n+\mu^L_{n-1})(\text{SUMHL}) + \frac{1}{8}\left(2- \frac{1}{L^T_{e_n}} - \frac{1}{L^T_{e_{n-1}}}\right)$$

$$\left(\frac{1}{S^T_{c_n}} + \frac{1}{S^T_{c_{n-1}}}\right)(\text{RURN})\,\frac{A^T_5}{4}\,\mu^T_{n-\frac{1}{2}}\,(\text{SUMHT})$$

$$\Delta\mathcal{C}^H = \left\{\frac{(\rho u r^\epsilon)_{m,n+1}+(\rho u r^\epsilon)_{m,n}}{2}\right\}\left\{A^L_4\left[\frac{\left(\frac{\mu^L}{P^L_r}\right)_{m,n+1}+\left(\frac{\mu^L}{P^L_r}\right)_{m,n}}{2}\right] + 2A^T_4\left(\frac{\bar{\mu}^T}{P^T_r}\right)_{m,n+1/2}\right\}$$

$$\left\{\frac{H_{m,n+1}-H_{m,n}}{\Delta\Psi}\right\}+\left\{\frac{(\rho u r^\epsilon)_{m,n}+(\rho u r^\epsilon)_{m,n+1}}{2}\right\}\left\{A^L_4\left[\frac{\mu^L_{n+1}\left(1-\frac{1}{P^L_r}\right)_{m,n+1}+3\mu^L_n\left(1-\frac{1}{P^L_r}\right)_{m,n}}{2}\right]\right.$$

$$\left. + A^L_4\left[\bar{\mu}^T_{n+1/2}\left(1-\frac{1}{P^T_r}\right)_{m,n+1/2}\right]\right\}\text{UAVG2} - \text{PARTH2}$$

4. The energy transport due to species gradients $\mathcal{C}^c$ is given by:

$$\Delta\mathcal{C}^c = \frac{1}{16}\left[\left(1-\frac{1}{L_e^L}\right)_{m,n+1} + \left(1-\frac{1}{L_e^L}\right)_{m,n}\right]\left[\left(\frac{1}{S_c^L}\right)_{m,n+1} + \left(\frac{1}{S_c^L}\right)_{m,n}\right]$$

$$\left[(\rho u r^{\epsilon})_{m,n+1}+(\rho u r^{\epsilon})_{m,n}\right]\left[A_5^L(\mu^L_{m,n+1}+\mu^L_{m,n})\right]\cdot\left[\frac{1}{4}\sum_i (h_{i_{m,n+1}}+h_{i_{m,n}})\right]$$

$$\left[\left(\frac{D^L_{ki}}{D^L}\right)_{m,n+1}\left(\frac{D^L_{ki}}{D^L}\right)_{m,n}\right]\left[\frac{(C_i)_{m,n+1}-(C_i)_{m,n}}{\Delta\Psi}\right] + \frac{1}{8}\left[\left(1-\frac{1}{L_e^T}\right)_{m,n+1} + \left(1-\frac{1}{L_e^T}\right)_{m,n}\right]$$

$$\left[\left(\frac{1}{S_c^T}\right)_{m,n+1} + \left(\frac{1}{S_c^T}\right)_{m,n}\right]\left[(\rho u r^{\epsilon})_{m,n+1}+(\rho u r^{\epsilon})_{m,n}\right]\left[A_5^{T-T}\mu_{m,n+1/2}\right]$$

$$\frac{1}{4}\sum_i\left[(h_{i_{m,n+1}}+h_{i_{m,n}})\right]\left[\left(\frac{D^T_{ki}}{D^T}\right)_{m,n+1}+\left(\frac{D^T_{ki}}{D^T}\right)_{m,n}\right]\left[\frac{(C_i)_{m,n+1}-(C_i)_{m,n}}{\Delta\Psi}\right]-\text{PARTC2}$$

5. Boundary layer swallowing and expansion of the boundary layer

An input number ϵ_H is used as a test value for calling a new inviscid streamline and to increment the Ψ grid. Two options are available based upon the value of ϵ_H. If $\epsilon_H = 0$, the streamline test is

not made. If ϵ_H is set to any positive number (the tolerance) the test

$$\left| \frac{H_{m+1}(L+1) - H_{m+1}(L-1)}{H_{m+1}(L+1)} \right| \leq \epsilon_H$$

is made. If the test fails, a new streamline is computed, or constant edge conditions are carried over.

6. Boundary conditions

   a. Initial - an input enthalpy profile vs. physical coordinates.

   b. Wall - $H_{m+1} = HH_1 + HH_2 \left(\frac{x}{Rn}\right) + HH_3 \left(\frac{x}{Rn}\right)^2 + HH_4 \left(\frac{x}{Rn}\right)^3 + HH_5 \left(\frac{x}{Rn}\right)^4$ where the HH_1 through HH_5 are input.

   c. Outer edge

      Enthalpy at the outer edge is obtained from the finite difference equation in Subsection II.D.2. or set equal to the input free stream value accordingly as the momentum, species or enthalpy slope tests are satisfied or not (see Subsections II.B.5., II.C.5., II.D.5. for formulation of tests).

III. INVISCID FLOW EQUATIONS

A. Governing Equations for One-Dimensional Streamlines

1. Momentum

$$u_{inv} \frac{du_{inv}}{ds} = - \frac{1}{\rho_{inv}} \frac{dp}{ds}$$

2. Species

$$u_{inv} \frac{dc_{i_{inv}}}{ds} = \frac{\dot{w}}{\rho_{inv}}$$

3. Total enthalpy (energy)

$$H = \text{constant}$$

$$= h_{inv} + \frac{u_{inv}^2}{2}$$

B. Tracing the Streamline from the Shock

Reference: NACA Report #1135 - "Equations, Tables and Charts for Compressible Flow 1953"

1. Intersection of streamline and shock, see sketch.

$$\frac{D_\infty}{2} \left(\frac{m_{bL}}{\rho_\infty u_\infty \pi} \right)^{\frac{1}{2}}$$

where

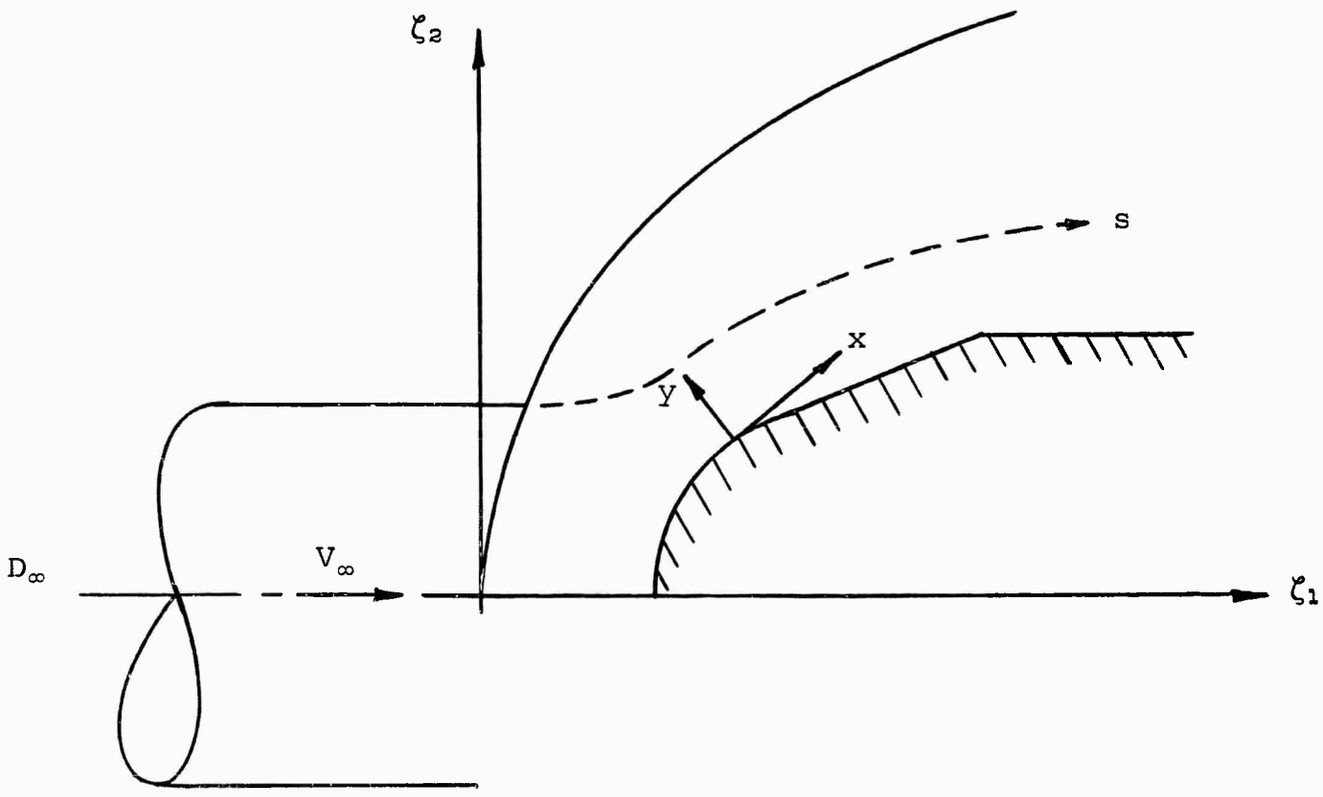
$$m_{bL} = \int_{o}^{\Psi_e} \epsilon \left[(2\pi)^{\epsilon} y \cos \theta_t \frac{d\Psi}{r^{\epsilon}} \right] + (2\pi)^{\epsilon} \Psi_e$$

θ_t = 90 - α, for arc, ogive

= 0, cylinder, flat plate

= cone angle, cone

α = angle which the current point on the body and the coordinates of the center of the arc make with ζ_1 axis, measured in a clockwise direction from ζ_1.



Coordinate Systems for a Blunt Body

2. Conditions downstream of the shock

a. Following will be input

ρ_∞

ρ_{stag}

h_∞, c_{p_∞} } needed for $T_\infty = \frac{h_\infty}{c_{p_\infty}}$

p_∞

altitude

γ (specific heat ratio)

u_{LOLIM} - used for checking against calculated u in the one-dimensional streamline equation in order to keep $u > 0$.

b. Following will be program set from input

$u_\infty = u(L)$

$c_{i_\infty} = c(L,I)$

$H_\infty = H(L)$

c. The program calculates:

$$u_{ds} = 1 - \left[\frac{[4(M_1^2 \sin^2 \theta - 1)(\gamma M_1^2 \sin^2 \theta + 1)]}{[(\gamma+1)^2 M_1^4 \sin^2 \theta]}\right]^{\frac{1}{2}} u_\infty$$

where

$$M_1 = \frac{u_\infty}{a_\infty} \text{ Mach \#}$$

$$a_\infty = \text{speed of sound} = 49.9 \sqrt{1.8\ T_\infty}$$

$$T_\infty = \frac{h_\infty}{C_{p_\infty}} {}^\circ K$$

$$\theta = \sphericalangle \text{ shock wave makes with } \zeta_1$$

$$c_{ids} = c_{i_\infty}$$

$$p_{ds} = \left[\frac{2\gamma\ M_1{}^2\ \sin^2\ \theta - (\gamma-1)}{\gamma + 1}\right] p_\infty$$

d. The program outputs:

(a) p_{ds}

(b) u_{ds}

(c) c_{ids}

3. Completion of streamline calculation

The program sets:

$$u_{m+1}(L) = u_{m+1}(L+1) = u_{m+1}(L+2)$$

$$c_{m+1}(L,I) = c_{m+1}(L+1,I) = c_{m+1}(L+2,I)$$

IV. INPUTS

Under this section the various input parameters are discussed from a programming viewpoint; see Manual, Part III, for input data preparation. In Subsection A through C, certain critical parameters are discussed, and in Subsection D the input definitions and card formats are specified. Also included in the latter sections of this report is a sample problem which illustrates the nature of the inputs.

A. Body Geometry

1. Classification

Bodies will be classified accordingly as the first geometrical region is:

a. Blunted $\Delta s \neq 0$

(a) arc (hemispherical nose)

b. Pointed $\Delta s = 0$

(a) cone

(b) ogive

(c) flat plate

where Δs = standoff distance from shock to stagnation point of body along centerline (see IV.B.3).

2. Subsequent geometric regions of the body

The following geometrical descriptions for body sections are available:

a. arc
b. cone
c. cylinder
d. ogive
e. flat plate

} 2 dimensional or axisymmetric depending upon input ϵ, (or EPSI in the input list, Subsection IV.D)

3. Calculation of radius of the body and the ζ_1, ζ_2 coordinates

a. For each region the program reads in

(a) INDP = pressure type indicator (see p.39, Section C)
- 1 = cosine
- 2 = polynomial
- 3 = quotient

(b) INDR = geometry indicator
- 1 = arc
- 2 = cone
- 3 = cylinder
- 4 = ogive
- 5 = flat plate

(c) INDLR = last subregion of last region indicator
- 1 = yes
- 0 = no

(d) INDLSR = last subregion of any region indicator { 1 = yes; 2 = no }

(e) OGIVE H, OGIVE K } coordinates of center of arc with respect to ζ_1, ζ_2 origin

(f) p(J), J = 1,8, pressure coefficients

(g) CC_i(K), K = 1,5, C_{WALL} coefficients

(h) Rn = nose or reference base radius

(i) XL = cumulative upper $\frac{x}{Rn}$ limit of this subregion

(j) CONEAN = cone angle/2 (vertex semi-angle)

B. Shock Geometry

1. Description of the Shock

The shock consists of up to 10 sections of the form:

a. $\zeta_2 = a_n\zeta_1 + b_n$ straight line

b. $\zeta_1 - a_n = b_n(\zeta_2 - c_n)^2$ parabola

Type 6 is a parabola whose coefficients a_n, b_n and c_n are specified as input. Type 7 is a parabola whose beginning and ending slopes and the ζ_1 projection of the end point of the geometrical shock region are specified as input.

The present version of the program permits parabolas to follow each other but they may not follow straight lines.

2. Shock input is specified by giving

   a. Curve type

   b. Slope and cumulative ζ_1 limit for a straight line

   c. Coefficients and cumulative ζ_1 limit for a parabola or

   d. Beginning and ending slopes and cumulative ζ_1 limit

3. Section 1 of the shock has optional provision (type 7) for internally computing and establishing the shock

$$\zeta_1 - a_n = b_n(\zeta_2 - c_n)^2$$

with

$$a_n = c_n = 0, \qquad b_n = \frac{.5}{1 + \frac{\Delta s}{Rn}} \frac{1}{Rn}$$

where $\Delta s = \frac{2/3}{\frac{\rho_{stag}}{\rho_\infty} - 1}$ Rn (physical standoff distance). $\frac{\Delta s}{Rn}$ is the dimensionless standoff distance.

4. The program has provision for specifying several shock shapes, e.g. conical, parabolic and normal. Moreover optional modes for specifying a particular shape are also possible, e.g.

parabolas can be specified by inputting the coefficients of the analytic expression or the beginning and ending slopes. The following indicates the formulae for obtaining the ζ coordinates and the balances of the shock coefficients for all permissible combinations of shock shapes.

a. Region 1 is a cone

i. m, ζ_1, $b_1 = 0$ are input

ii. $\zeta_2 = m\,\zeta_1$

b. Region N-1 is a parabola

Region N is a parabola - Type 6

i. a_{N-1}, b_{N-1}, c_{N-1} are available

a_N, b_N, c_N are input

ii. $\zeta_{1\,(N-1)} = a_{N-1} + b_{N-1}\,[\zeta_{2\,(N-1)} - c_{N-1}]^2$

$$\zeta_2 = \frac{b_{N-1}\,c_{N-1} - b_N c_N}{b_{N-1} - b_N}$$

c. Region N-1 is a parabola

Region N is a parabola - Type 7

i. a_{N-1}, b_{N-1}, c_{N-1} are available

m_{N-1}, m_N, ζ_{1N} are input

ii. $$a_N = \frac{\zeta_{1\,(N-1)} m^2_{N-1} - m^2_N \zeta_{1\,(N)}}{m^2_{N-1} - m^2_N}$$

$$c_N = \zeta_{2\,(N-1)} - \frac{2m^2_N(\zeta_{1\,(N)} - a_N)}{m_{N-1}}$$

$$b_N = \frac{1}{4m^2_N(\zeta_{1\,(N)} - a_N)}$$

$$\zeta_{2\,(N-1)} = \frac{1}{2b_{N-1}\, m_{N-1}} + c_{N-1}$$

$$\zeta_{1\,(N-1)} = a_{N-1} + b_{N-1}(\zeta_{2\,(N-1)} - c_{(N-1)})^2$$

d. Region N-1 is a parabola

Region N is a cone

i. a_{N-1}, b_{N-1}, c_{N-1} are available

m_N is input

ii. $$\zeta_{2\,(N-1)} = \frac{1}{2b_{N-1}\, a_N} + c_{N-1}$$

$$\zeta_{1\,(N-1)} = a_{N-1} + b_{N-1}[\zeta_{2\,(N-1)} - c_{N-1}]^2$$

$$b_N = \zeta_{2\,(N-1)} - a_N \zeta_{1\,(N-1)}$$

e. Region N-1 is a cone

Region N is a cone

i. a_{N-1}, b_{N-1}, $\zeta_{1\,(N-1)}$ are available

m_N is input

ii. $\zeta_{2\,(N-1)} = a_{N-1}\,\zeta_{1\,(N-1)} + b_{(N-1)}$

$b_N = \zeta_{2\,(N-1)} - a_N \zeta_{1\,(N-1)}$

C. Pressure Distribution

Associated with each body subregion is a distribution which is one of 3 possible types:

1. $p = p_1 \cos^2 \frac{x}{Rn}$ (Newtonian)

2. $p = p_2 + p_3 \frac{x}{Rn} + p_4 \left(\frac{x}{Rn}\right)^2 + p_5 \left(\frac{x}{Rn}\right)^3 + p_6 \left(\frac{x}{Rn}\right)^4$

3. $p = \frac{p_7}{p_8 + \frac{x}{Rn}}$

where p_1 through p_8 are inputs.

D. Input Definitions, Card Formats and Symbols

SYMBOLS	DEFINITION	FORMAT
*LP2	# Ψ pts + 2	I 10
NS	# species	
NPSI	print interval density in Ψ direction e.g. every point, every second point, etc.	
INDSTR	streamline starting point indicator	
FNDSSL	lower limit for step size control	E 10.3
FNDSSH	upper limit for step size control	
IALT	altitude - in kft	I 10
A_1^L	laminar indicator for momentum equation	E 10.3
A_1^T	turbulent indicator for momentum equation	
A_2	chemistry indicator for equilibrium or non-equilibrium calculations (see p.18, Section b)	
A_3^L	laminar indicator for species equation	
A_3^T	turbulent indicator for species equation	
A_4^L	laminar indicator for energy equation	
A_4^T	turbulent indicator for energy equation	
A_5^L	laminar indicator for energy equation	
A_5^T	turbulent indicator for energy equation	
c(N,I)	species mass fraction profiles N = 1,2...LP2; I = 1,2,4,5,6	
*RESTAR	restart indicator; 1 = original run, 0 = continuation run	E 10.3

SYMBOL	DEFINITION	FORMAT
DELTAX	step size - x direction	E 10.3
EPSI	exponent for body radius	
EPSIU=ϵ_u	tolerance on velocity for a streamline call	
EPSIC=ϵ_c	tolerance on all species for a streamline call	
EPSIH=ϵ_H	tolerance on total enthalpy for streamline call	
EPSIT=ϵ_T	tolerance on temperature iteration	
FH(N)	total enthalpy profile, N = 1,2...LP2	
FK	factor in $\bar{\mu}^{T1}$	
*CPE	free stream specific heat at constant pressure	E 10.3
FL	characteristic length to dimensionalize species production term	
FSHE	free stream static enthalpy	
GAMM	ratio of specific heat, Cp/Cv	
PE	free stream pressure	
RHOE	free stream density	
RHOSTG	stagnation density	
CE(I)	free stream species, I = 1,2...7	
R_N	nose radius	
UINF	free stream velocity	
ULOLIM	low limit for velocity in streamline	
XS	x starting value	

SYMBOL	DEFINITION		FORMAT
Z1S	ζ_1 coordinate starting value		E 10.3
Z2S	ζ_2 coordinate starting value		
Z1L	ζ_1 coordinate entire body		
u(N)	velocity profile, N = 1,2,...LP2		
*FA	coefficient for FKPSI in μ^{T2}		E 10.3
FB	FKPSI ≡ K(N) (see p.8, Section ii)		
FC			
TESTRA	test ratio for establishing turbulent viscosity model		
AB_1^T	law of the wall - dimensional coordinate y	Indicators and coefficients for invoking turbulent viscosity model components (see p.7, Section 4,b)	E 10.3
AB_2^T	law of the wake - dimensional coordinate, y_e		
AB_3^T	laminar viscosity		
AB_4^T	eddy viscosity fit dimensional coordinate y		
AB_5^T	law of the wall - streamline coordinate, Ψ		
AB_6^T	law of the wake - streamline coordinate, Ψ_e		
AB_7^T	eddy viscosity fit streamline coordinate, Ψ		
BB_1^T	law of the wall - dimensional coordinate, y		

SYMBOL	DEFINITION		FORMAT
BB_2^T	law of the wake - dimensional coordinate, y_e	Indicators and coefficients for invoking turbulent viscosity model components (see p.7, Section 4,b)	E 10.3
BB_3^T	laminar viscosity		
BB_4^T	eddy viscosity fit dimensional coordinate, y		
BB_5^T	law of the wall - streamline coordinate, Ψ		
BB_6^T	law of the wake - streamline coordinate, Ψ_e		
BB_7^T	eddy viscosity fit streamline coordinate, Ψ		
FLELIN	Lewis laminar number		E 10.3
FLETIN	Lewis turbulent number		
PRALIN	Prandtl laminar number		
PRATIN	Prandtl turbulent number		
SCHLIN	Schmidt laminar number		
SCHTIN	Schmidt turbulent number		
Y(N)	physical coordinates for input profile normal to body		
*INDPRI	print interval x direction		I 10
NSR	# shock regions		
JINPUT	# times to bypass step size control halving		
THPER	% to be used to establish boundary layer thickness		E 10.3

SYMBOL	DEFINITION	FORMAT
*ASR(N) BSR(N) CSR(N)	coefficients for N^{th} shock region geometry, N = 1, NSR	E 10.3
Z1R(N)	ζ_1 boundary for N^{th} shock region, N = 1, NSR	
Z2R(N)	ζ_2 boundary for N^{th} shock region, N = 1, NSR	
INDTYP(N)	geometric type, N = 1, NSR	I 3
INDCOO(N)	end coordinate indicator, N = 1, NSR	I 3
INDLAS(N)	last shock region indicator, N = 1, NSR	I 4
Note: ASR(N)-INDLAS(N) are repeated for each shock region, N = 1, NSR		
*INDP	body subregion pressure type	I 10
INDR	body subregion geometric type	
INDLR	last region indicator	
INDLSR	last subregion indicator	
INDS5	spare	
INDS6	spare	
INDS7	spare	
OGIVEH OGIVEK	coordinates of center of body arcs or ogives	E 10.3
P(J)	coefficients for pressure formulas, J = 1,8	
CC(K,I)	coefficients for species mass fractions at wall, K = 1,5; I = 1,NS-1	

SYMBOL	DEFINITION	FORMAT
HH(J)	coefficients for total enthalpy at wall, J= 1,5	
R_N	body radius	
X_L	cumulative x limit for each subregion	
CONEAN	cone angle	

Note: INDP-CONEAN are repeated for each body subregion

*Indicates that this field is the first one on the input card, and subsequent fields until the next * are continuous through column 70 for as many cards as are necessary.

V. PROGRAM FEATURES

A. Step Size Control

The purpose of step size control is to allow the program to run as fast as possible within stability and truncation requirements.

1. Ψ direction

Whenever the number of Ψ intervals becomes twice the original input amount (as a result of swallowing) the program halves the number of points. This is of significance since the permissible stability control step size in the x direction varies with $(\Delta\Psi)^2$.

2. x direction

The program takes two single steps and compares the velocity, species and enthalpy with the results of a single step of double size. Depending on input limit tolerances, the step size is doubled, unchanged or halved. However, the step size is always subjected to the stability control for maximum size.

If a negative velocity, specie, enthalpy or temperature has been calculated, or depending on a sense switch being on, if a 5% out of monotonicity in u or H develops, the step size is halved up to seven times before the program stops. Provision has been made for overriding the halving for JINPUT times, so as

to allow zero species to fill in as a result of production and of diffusion in the Ψ direction. The above procedure for doubling, continuing and halving the step size which applies to the boundary layer also applies individually to u and c_i in the streamline calculations.

B. Stability Control

The expansion of the step size in the x direction which is described under "Step Size Control" is subsequently scrutinized to insure stability.

Δx is compared to $\frac{\overline{\Delta\Psi}^2}{2\sigma_n}$ and accordingly as it is less than (or equal to) or greater than, it is accepted or halved.

$$\sigma_u = r_m^{\epsilon} r_m^{\epsilon} \rho_n u_n \left[A_1^L \mu_n^L + A_1 \left[\frac{\bar{\mu}_{n+1/2}^T + \bar{\mu}_{n-1/2}^T}{2} \right] \right]$$

$$\sigma_H = r_m^{\epsilon} r_m^{\epsilon} \rho_n u_n \left[A_4^L \frac{\mu_n^L}{P_{r_n}^L} + A_4^L \frac{\bar{\mu}_{n+1/2}^T + \bar{\mu}_{n-1/2}^T}{2} \frac{1}{P_{r_n}^T} \right]$$

$$\sigma_C = r_m^{\epsilon} r_m^{\epsilon} \rho_n u_n \left[A_3^L \frac{\mu_n^L}{S_{c_n}^L} \frac{D_k^L}{D_n^L} + A_3^T \frac{\bar{\mu}_{n+1/2}^T + \bar{\mu}_{n-1/2}^T}{2} \frac{1}{S_{c_n}^T} \frac{D_k^T}{D_n^T} \right]$$

Δx must be $\leq$ the minimum of $\frac{\overline{\Delta\Psi}^2}{2\sigma_u T_{ln}}$, $\frac{\overline{\Delta\Psi}^2}{2\sigma_H T_{ln}}$, $\frac{\overline{\Delta\Psi}^2}{2\sigma_C T_{ln}}$ in order to insure stability.

C. Conversion from Physical to Streamline Coordinates

1. The various input profiles are given as functions of the physical coordinate Y, which may be unevenly spaced. The number of Ψ intervals equals the input number of Y intervals and is equal to L - 1.

2. The streamline coordinate $\Psi = \int_0^Y \rho u r^\epsilon dy$ is calculated and then equispaced over the thickness.

3. The corresponding Y's are developed from $Y = \int_0^\Psi \frac{1}{\rho u r^\epsilon} d\Psi$ with $Y(0) = 0$.

4. A table lookup routine is used to linearly interpolate the dependent variables, u, C_i, H.

5. The calculated value of Y_{max} is compared with the input value of Y_{max} (see Input, Section IV.D). If the difference is greater than .1%, the following on line message is printed: "YCALC(L) = Y(L) = ".

D. Continuation Procedure

At any time during the running of the program sense switch 4 can be depressed and an on-line punch of the continuation quantities will occur. This makes it possible to continue the program at a later date.

When the program is continued with on-line punched cards,

RESTAR must be set equal to zero.

E. Output Control

Based on the input quantity INDPRI, output at every n^{th} station is obtained and based on NPSI, output at every m^{th} Ψ level. There is also provision in the streamline calculation to obtain output whenever the step size doubles.

F. Streamline Control

An initial value or a complete body problem can be solved depending on whether we input a 0 or 1 for INDSTR. Thus there are two possible starting points for a streamline calculation:

1. The starting profile at the starting point on the body.
2. The starting profile at the point of intersection of the streamtube and the shock.

In addition, the first option can be additionally modified to constant edge conditions, i.e., $u_{m+1}(L+3) = u_e$, $C_{i,m+1}(L+3) = C_{e,i}$, $H_{m+1}(L+3) = H_e$, by setting INDSTR = - 1.

G. Sense Switch Control

Is available for diagnostic and monitoring purposes and can be specifically determined by consulting the source language.

H. Additional Programming Logic

1. Momentum equation

a. In order to step forward the required ρ is obtained as follows:

$$h(\Psi) = H(\Psi) - \frac{u^2(\Psi)}{2}$$

Using as our first approximation for T

$$T_i(\Psi) = \left[h - C_O \frac{D_{O2}}{2m_O} - C_N \frac{D_{N2}}{2m_N} - \frac{C_{NO}}{m_{NO}} \left(\frac{D_{N2}+D_{O2}}{2} - D_{NO} \right) \frac{C_{NO^+}}{m_{NO^+}} \left(I_{NO} + \frac{D_{N2}+D_{O2}}{2} - D_{NO} \right) \right] \Big/ C_p$$

calculate

$$\Lambda_j = \left(\frac{T_j^V}{T} \right) \Big/ \left(e^{T_j^V / T} - 1 \right)$$

and solve for T_{i+1}

$$h = RT_{i+1} \left[\sum_j \frac{C_j}{M_j} \left(\Lambda_j + \frac{7}{2} \right) + \frac{5}{2} \sum_k \frac{C_k}{M_k} \right] + C_O \left(\frac{D_{O2}}{2m_O} \right) + C_N \left(\frac{D_{N2}}{2m_N} \right) + \frac{C_{NO}}{m_{NO}} \left(\frac{D_{N2}+D_{O2}}{2} - D_{NO} \right) + \frac{C_{NO^+}}{m_{NO^+}} \left(I_{NO} + \frac{D_{N2}+D_{O2}}{2} - D_{NO} \right)$$

$j = O_2, N_2, NO, NO^+$

$k = O, N, e$

if $\left|\frac{T_{i+1}-T_i}{T_{i+1}}\right| < \epsilon_T$ we use T_{i+1}, otherwise continue the iteration cycle at Λ.

b. p(x) is chosen according to the indicator for the subregion and we compute

$$\rho = \frac{p}{RT \sum_i \frac{C_i}{M_i}}$$

c. Because the nature of the u profile is not linear in the neighborhood of the wall, $u_{\frac{1}{2}}$ is obtained by assuming $u = a\Psi^{\frac{1}{2}} + b\Psi$ and determining a and b from u_2 and u_3. The derivative at the 1/2 point is obtained by differentiating u.

d. If a velocity is negative or if both sense switch 5 is depressed and a 5% out of monotonicity occurs, then the step size is halved and the calculation repeated. If after halving seven times, the velocity is still negative, the program stops.

2. Species equation

If a species is negative, the step size is halved and the calculation repeated. If after halving the step size seven times, a species is still

negative, the program stops. $C_{\frac{1}{2}}$ is obtained by assuming $C = C_w + a\Psi^{\frac{1}{2}} + b\Psi$ and determine a and b from C_2 and C_3. The derivative at the 1/2 point is obtained by differentiating C.

3. Enthalpy equation

Halving of the step size will result when a negative enthalpy occurs.

If after seven halvings, this condition persists, the program will halt.

$H_{\frac{1}{2}}$ is obtained by assuming $H = H_w + a\Psi^{\frac{1}{2}} + b\Psi$ and determine a and b from H_2 and H_3. The derivative at the 1/2 point is obtained by differentiating H.

VI. PROGRAMMED STOPS AND PAUSES

PROGRAM	STOP NO. Displayed in Address Field of Storage Register	MEANING
MAIN	17	$\epsilon < 0$
	77	Shock geometry is cone followed by parabola
	310	$A_i^{L,T} < 0$
	650	$K_s < 1$
	2575	$LP_2 \geq 99$
	2655	$L > 2$ (LORIG)
CEDGE(J)	60	$J < 1$
	71	$C_{w,i}$ or $\Sigma C_{w,i}$ is in error
RADBDY	550	$\epsilon < 0$
STEPSZ	603 (Pause)	Δx has been halved 7 times Additional 7 times can be obtained by depressing START
UCSTRE	21	$\frac{D_\infty}{2}$ is not in any shock region
UEDGE(J)	30	$J < 1$
	50	$J > 3$

VII. OPERATING PROCEDURE

A. Original Run

Standard 7094 Fortran operating procedure is employed with RESTAR = 1.0E0. Program language is FORTRAN II.

B. Continuation Run

Remove subregion parameter cards that were read in during previous run. Insert continuation cards after problem input and ahead of remaining subregion cards. Set RESTAR = 0E0.

There is present the option of modifying the original input or the continuation input by repunching the appropriate fields or cards. It should be noted that the continuation cards are necessarily in octal in order to preserve full significance.

APPENDIX 1

DIMENSIONS OF VARIABLES

APPENDIX 1

DIMENSIONS OF VARIABLES

The units of the variables which appear in the equations are listed below. The conversion constants required for consistency are indicated.

A. Momentum Equation

1. The units for the quantities involved are

$$\rho = \frac{\text{lb sec}^2}{\text{ft}^4} \text{ or } \frac{\text{slugs}}{\text{ft}^3}$$

$$u = \text{ft/sec}$$

$$p = \text{lbs/ft}^2$$

$$\frac{dp}{ds} = \text{lbs/ft}^2, \text{ s is nondimensional}$$

$$\frac{dp}{dx} = \text{lbs/ft}^3, \text{ x is in feet}$$

$$\tau = \text{lbs/ft}^2$$

$$\mu = \frac{\text{lbs sec}}{\text{ft}^2}$$

$$\frac{d\tau}{dy} = \text{lbs/ft}^3$$

2. In order for ρ to have the units $\frac{\text{lbs sec}^2}{\text{ft}^4}$ R should be expressed in the following units:

$$\frac{\text{lb sec}^2}{\text{ft}^4} = \rho = \frac{p}{RT\,\Sigma C/M} = \frac{\text{lb/ft}^2}{\text{R}\cdot\text{K}\,\frac{\text{mole}}{\text{gm}}}$$

$$R = \frac{\text{gm ft}^2}{^\circ\text{K mole sec}^2}$$

$$= 8.31657 \times 10^3 \text{ joule (kilogram mole}^{-1}) \,^\circ\text{K}^{-1}$$

$$= \frac{1}{1.356}\,\frac{\text{ft lbs}}{\text{joules}}\; 453.6\,\frac{\text{gm}}{\text{lb}}\; 32.2\ \text{ft/sec}^2$$

$$= 8.95805 \times 10^7\ \frac{\text{gm ft}^2}{^\circ\text{K (kilogram mole) sec}^2}$$

$$= 8.95805 \times 10^4\ \frac{\text{gm ft}^2}{^\circ\text{K (gram mole) sec}^2}$$

3. In order for T to have the units $^\circ$K the following adjustments must be made:

$$T = \frac{h - \frac{D_{O2}}{m_O}}{C_p} = \frac{\frac{\text{ft}^2}{\text{sec}^2} - \left(\frac{\text{ev}}{\text{part}}\right)\frac{1}{\text{gm}}}{\frac{\text{ft}^2}{\text{sec}^2\ \text{K}}} = {}^\circ\text{K} - \frac{\text{ev sec}^2\ {}^\circ\text{K}}{\text{part gm ft}^2}$$

Taking the second term

$$\frac{\text{ev sec}^2\ {}^\circ\text{K}}{\text{part gm ft}^2} 453.6\ \frac{\text{gm}}{\text{lb}}\ 32.2\ \frac{\text{ft}}{\text{sec}^2}\ \frac{1}{1.356}\ \frac{\text{ft lb}}{\text{joule}}\ \frac{1\ \text{joules}}{6.24 \times 10^{18}\ \text{ev}}$$

$$= 1726 \times 10^{-18}\ (^\circ\text{K})$$

Thus for all $\frac{D}{m}$ terms, this factor should be used, i.e.

$$\frac{D}{m} = 1726 \times 10^{-18} \left(\frac{\bar{D}}{m} \right)$$

B. Species Equation

1. The units for the quantities involved are

$\dot{w} = \frac{\text{lb sec}}{\text{ft}^4}$ which is derived from

$$\dot{w} = \rho u \frac{dC_i}{dx}$$

2. ρ_{DO} should be of the same units as ρ for Eq. (7a), p. 5 of GASL TR-246. Hence,

$$\rho_{DO} = \frac{\text{gm/mole}}{\frac{\text{particle}}{\text{mole}}\ (\text{ft lbs sec})^3} \left(\frac{\text{gm}}{\text{part}}\ \frac{\text{ft lb}}{{}^\circ\text{K}}\ {}^\circ\text{K} \right)^{3/2}$$

$$= \frac{\text{gm}^{5/2}}{(\text{ft lbs})^{3/2}\ \text{sec}^3\ \text{part}^{5/2}} \left(\frac{1}{453.6}\ \frac{\text{lb}}{\text{gm}} \right)^{5/2} \left(\frac{1}{32.2}\ \text{sec}^2/\text{ft} \right)^{5/2}$$

$$= 3.87871 \times 10^{-11}\ \frac{\text{lbs sec}^2}{\text{ft}^4}\ \bar{\rho}_{DO}$$

Similarly for ρ_{DN}, ρ_{DNO}, ρ_{DE}

3. σ, γ, $\bar{K}$ are dimensionless

4. A, B, C, K develop as follows (example for A shown below)

$$\frac{\text{ft}}{\text{gm/mole}}\left[\frac{1}{\frac{\text{gm}}{\text{mole}}}\ \frac{\text{cm}^6}{\text{part}^2\,\text{sec}}\right]\left[\frac{\text{lb sec}^2}{\text{ft}^4}\right]\left[\frac{\text{lb sec}^2}{\text{ft}^4}\right]$$

$$A = \frac{\text{mole}^2\,\text{cm}^6\,\text{sec}^3\,\text{lb}^2}{\text{ft}^7\,\text{gm}^2\,\text{part}^2}\left[453.6\ \frac{\text{gm}}{\text{lb}}\right]^2\left[\frac{1}{2.54}\ \frac{\text{in}}{\text{cm}}\ \frac{1}{12}\ \frac{\text{ft}}{\text{in}}\right]^6\left[6.0251\times10^{23}\ \frac{\text{part}}{\text{mole}}\right]$$

$$= 4.9778\times10^{21}\ \frac{\text{mole sec}}{\text{part}}\ \bar{A}$$

5. D, E, F develop as follows (example for D shown below)

$$\frac{\text{ft}}{\frac{\text{gm}}{\text{mole}}}\ \frac{\text{cm}^3}{\text{part sec}}\ \frac{\text{lb sec}^2}{\text{ft}^4}$$

$$D = \frac{\text{mole cm}^3\ \text{sec lb}}{\text{ft}^3\ \text{gm part}}\ 453.6\ \frac{\text{gm}}{\text{lb}}\left(\frac{1}{30.48}\ \frac{\text{ft}}{\text{cm}}\right)^3$$

$$= 1.6018\times10^{-2}\ \frac{\text{mole sec}}{\text{particle}}\ \bar{D}$$

6. Equation (9), p. 7 of GASL TR-246 would yield (neglecting $\frac{M_o}{\rho}$)

$\Sigma \dot{w}_i = \frac{\text{mole sec}}{\text{part}}$ but $\frac{\text{lb sec}}{\text{ft}^4}$ are required hence

$$\frac{\text{mole sec}}{\text{part}} \rho \frac{\text{lb sec}^2}{\text{ft}^4} 32.2 \text{ ft/sec}^2 \; 6.0251 \frac{\text{part}}{\text{mole}} \times 10^{23} \frac{1}{L} \text{ ft}$$

$$\dot{w} = 1.94008 \times 10^{25} \frac{\rho}{L} \left[\qquad \right] \frac{\text{lb sec}}{\text{ft}^4} \; \bar{\dot{w}}_i$$

7. In A, B, etc. $\frac{D_{O2}}{KT}$ should be dimensionless. This can be accomplished by setting

$$\frac{D_{O2}}{KT} = \frac{\frac{\text{ev}}{\text{particle}}}{\frac{\text{ft lbs}}{^\circ\text{K}} \; ^\circ\text{K}} \times 1.356 \frac{\text{joules}}{\text{ft lb}} 10^7 \frac{\text{erg}}{\text{joule}} \frac{1}{1.6021 \times 1^{-12}} \frac{\text{ev}}{\text{erg}}$$

$$= .846389 \times 10^{19} \left(\frac{\bar{D}_{O2}}{KT} \right)$$

C. Energy Equation

1. The units for the quantities involved are:

$$H = \frac{\text{ft}^2}{\text{sec}^2}$$

$$h_i = \frac{\text{ft}^2}{\text{sec}^2}$$

$$D_{Ki} = \frac{\text{ft}^2}{\text{sec}}$$

APPENDIX II

PROGRAM SOURCE LANGUAGE

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CHMREL PAGE 1

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C       CHEMICALLY REACTING BOUNDARY LAYER
        COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AE1T,AB2T,
       1AB3T,AB4T,AL5T,AB6T,AE7T,AC12,AH12,ALPHA,ASH,AL12,B1T,B2T,B3T,
       2B4T,B5T,B6T,B7T,BE1T,BE2T,BE3T,BE4T,BE5T,BB6T,BE7T,BC12,BH12,
       3BLOCK,BSR,BL12,C,C12,CL,CCALC,CE,CP,CM1,CM2,CONEAN,CP,CPE,CS,
       4CSR,CCLF12,DEL,DELTAP,DELTAX,DELXCI,DELXST,DMDF12,DIST,DKDL,
       5EKET,EM2,EM2DC2,EME,EC2,ESCRIP,ETDF12,ELEMS,EPSI,
       6EPSIC,EPSIP,EPSII,EPSIC,ETA,FA,FE,FC,FECA,FEDL,
       7FEDC,FF,FF12,FFCALC,FFE,FFP,FFM2,FFS
        COMMON FINC,FR,FRPSI,FL,FLEFIN,FLETIN,FLEML,FLEMI,
       1FLN2,FLNC,FLNE),FLC2,FP,FMDL,FMDL12,FMLTIM,FMUTIP,FNDSSH,
       2FNESSL,FSF,FSFE,FSFI,FSFI2,FSFI,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
       3FSPFI,FSPFE,FSPFP,FSME,FSMN,FSMNC,FSMNCP,FSMP,GAMM,HE,
       4HM,IALT,ILEL,INDCOC,INCLAS,INEF,INEPRI,INEPS,INDF,
       5INDSTF,INDSTR,INDTY),JINPUT,JS,KS,L,LP2,MPSI,NS,NSK,
       6OCDIVE,OCDIVER,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRLIRA
        COMMON PRDS,PRF,PRSAVE,PS,PSCALC,PSI,PSITOC,QM,R,RESTAR,RHC,
       1RHDCAL,RHDE,RHF12,RHDSTC,RP,RRS,RS,RSC,RSM,SCHLIN,SCHTIN,
       2SCL,SCT,SHARDL,SIGMAC,SIGMAM,SIGMAS,
       3STALIS,T,TAUM,TAUP,TESTRE,THETAI,THPEP,TIM,
       4TITLE1,TITLE2,TITLE3,TP,TWR2,
       5TWRC,TWNDP,TWC2,U,U12,UCALC,UE,UINF,ULCLIM,UM,UM1,
       6UM2,US,WDOT,X,XI,XL,XLS,XRM,XS,XU12,Y,YCALC,YTM,YTMC,
       7YTMD,Z1,Z2,Z1R,Z1...,Z2P,Z2S
        COMMON RETRET,RKEX,RKEM,FRDPEX,FNUREM,CSLB,IPRINT,NCCUNT,JBYCTR
       1,FSF12,T12,Y12,STALL,STPCE,RPCC12,AAL
C
        DIMENSION AL12(10),ASH(10),E1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
       1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
       2CCL(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
       3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
       4EDENS(60),FF(60),FMCALC(60),FMM(60),FMP2(60),FMS(60),
       5FMPSI(60),FLEML(60),FLEMT(60),FLN2(60),FLNC(60),
       6FLNE(60),FLC2(60),FM(10),FMDL(60),FMLTIM(60)
        DIMENSION FMUTIP(60),FSF(60),FSFI(60,10),FSFI12(10),FSKRA(10),
       1FSKRB(10),FSKRC(10),FSKRD(10),MM(5),INDCOC(10),
       2INDCAS(10),INDPS(50),INDTYP(10),F(6),PRDIRA(60),
       3PRAL(60),PRAT(60),PS(6,50),PSCALC(60),PSI(60),RHO(60),
       4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
       5SIGMAM(60),SIGMAL(60),T(60),TAUM(60),TAUP(60),
       6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
        DIMENSION UCALC(60),UP(60),UM1(60),UM2(60),US(60),
       1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTMC(10),Z1R(10),
       222R(10)
C
    1 READ INPUT TAPE 5,5CCC,TITLE1,TITLE2,TITLE3
      WRITE OUTPUT TAPE 6,5CC1
      WRITE OUTPUT TAPE 6,5CC2
      WRITE OUTPUT TAPE 6,5CC3,TITLE1,TITLE2,TITLE3
      READ INPUT TAPE 5,2,LP2,NS,NPS1,INDSTR,FNDSSL,FNDSSH,IALT,A1L,A1T
     1,A2,A3L,A3T,A4L,A4T,A5L,A5T,(((C(N,I),N=1,LP2),I=1,2),((C(N,I),N=1,
     2LP2),I=4,6)
    2 FORMAT (4I1C,2E1C.3,I1C/(7E10.3))
      L=LP2-2
      LLR1G=L
```

```
      LCRP1=L+1
      NSM1=NS-1
      READ INPUT TAPE 5,5,RESTAR,DELTAX,EPSI,EPSIU,EPSIC,EPSIM,EPSIT,
     1(FM(N),N=1,LP2),FK
      DELXST=DELTAX
    5 FORMAT (7E10.3)
      READ INPUT TAPE 5,5,CPE,FL,FSME,GAMM,PE,RHOE,RHOSTG,(CE(I),I=1,NS)
     1,RN,UINF,UDELTA,XS,Z1S,Z2S,Z1L,(U(N),N=1,LP2)
      READ INPUT TAPE 5,5,FA,FB,FC,TESTRA,AB1T,AB2T,AB3T,AB4T,AB5T,AB6T,
     1AB7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,FLELIN,FLETIN,PRALIN,PRATI
     2N,SCHLIN,SCHTIN,(Y(N),N=1,LP2)
      CALL CDIFFC(1)
    9 DO 11 N=1,LP2
      C(N,7)=FM(7)/FM(E)*C(N,E)
   11 C(N,3)=1.0-C(N,1)-C(N,2)-C(N,4)-C(N,5)-C(N,6)-C(N,7)
      LE=L(L)
      IF(INDSTR) 13,13,16
   13 DO 15 I=1,NS
   15 CE(I)=C(L,I)
   16 RHE=RR(L)
      RS=Z2S
      IF(EPSI) 17,18,19
   17 STOP 17
   18 RS=1.0
   19 RS=0
   20 READ INPUT TAPE 5,25,INDPRI,NSR,JINPUT,THPER,(ASR(N),BSR(N),CSR(N)
     1,Z1R(N),Z2R(N),INDTYP(N),INDLCC(N),INDLAS(N),N=1,NSR)
   25 FORMAT(3I1C,E10.3/(5E10.3,2I3,I4))
      IF(INDTYP(1)-6)32,32,30
   30 ASR(1)=0
      CSR(1)=0
      STAGIS=(.6666*RHOE)/(RHOSTG-RHOE)*RN
      BSR(1)=.5/(RN*STAGIS)
   32 N=2
   63 IF(INDLAS(N-1))65,65,50
   65 IF(INDTYP(N-1)-6)66,70,70
C     REGION N-1 IS A CONE
   66 IF(INDTYP(N)-6)75,76,76
C     REGION N-1 IS A PARABOLA
   70 IF(INDTYP(N)-6)81,84,87
C     CONE CONE
   75 Z2R(N-1)=ASR(N-1)*Z1R(N-1)+BSR(N-1)
   76 BSR(N)=Z2R(N-1)-ASR(N)*Z1R(N-1)
      GO TO 99
C     CONE PARABOLA
   78 STOP 77
C     PARABOLA CONE
   81 Z2R(N-1)=.5/BSR(N-1)/ASR(N)+CSR(N-1)
      IF(INDUCC(N-1))82,82,78
   82 Z1R(N-1)=ASR(N-1)+BSR(N-1)*(Z2R(N-1)-CSR(N-1))**2
      GO TO 78
C     PARABOLA PARABOLA 6
   84 Z2R(N-1)=(BSR(N-1)*CSR(N-1)-BSR(N)*CSR(N))/(BSR(N-1)-BSR(N))
      IF(INDCCC(N-1))85,85,99
   85 Z1R(N-1)=ASR(N-1)+BSR(N-1)*(Z2R(N-1)-CSR(N-1))**2
      GO TO 99
```

```
C       PARABOLA PARABOLA 7
   87 SLOPE1=ASR(N)
      SLOPE2=BSR(N)
      Z2R(N-1)=.5/BSR(N-1)/SLOPE1*(CSR(N-1)
      IF(INDCCL(N-1))6,88,85
   88 Z1R(N-1)=ASR(N-1)+BSR(N-1)*(Z2R(N-1)-CSR(N-1))**2
   89 ASR(N)=(Z1R(N-1)*SLOPE1**2-SLOPE2**2*Z1R(N))/(SLOPE1**2-SLOPE2**2)
      CSR(N)=Z2R(N-1)-2.0*SLOPE2**2*(Z1R(N)-ASR(N))/SLOPE1
      ESR(N)=.25/SLOPE2**2/(Z1R(N)-ASR(N))
      GO TO 95
   90 IF(INDTYP(N-1)-1)100,100,91
   91 IF(INDTYP(N-1)-2)92,94,94
   92 Z2R(N-1)=ASR(N-1)*Z1R(N-1)+ESR(N-1)
      GO TO 100
   94 Z2R(N-1)=CSR(N-1)+SQRT((Z1R(N-1)-ASR(N-1))/BSR(N-1))
      GO TO 100
   95 N=N+1
      GO TO 83
  100 IF(RESTAR) 210,175,210
  175 READ INPUT TAPE 5,2761,KS,(INDFS(N),N=1,KS),L,LP2,(INDFSC,INDP,INDR
     1,INDLR,INDLSR
  180 READ INPUT TAPE 5,2765,X,DELTAX,(U(N),N=1,LP2),
     1((V(N,I),N=1,LP2),I=1,KS),(PH(N),N=1,LP2),(PS(N),N=1,LP2),
     2DELTAP,(Y(N),N=1,LP2),Z1,Z2,Z1S,Z2S,CG1VEH,CG1VEK,(P(J),J=1,8),
     3((CC(K,I),K=1,5),I=1,KS),(PP(J),J=1,5),RN,XL,CGNEAR,((PS(J,1),J=1,
     46),I=1,KS),(RS(N),N=1,KS),(XS(N),N=1,KS),ALPHA,XS,RS,RSP
      CALL CGREAD(3)
      GO TO 680
  210 CALL STACUT(1)
  300 INDFSL=0
  305 IF(A1L) 310,315,315
  310 STOP 310
  315 IF (A1T) 310,325,325
  325 IF(A2L) 310,335,335
  335 IF(A2T) 310,345,345
  345 IF(A4L) 310,355,355
  355 IF(A4T) 310,365,365
  365 IF(A5L) 310,375,375
  375 IF(A5T) 310,400,400
  400 X=XS+DELTAX
  500 FORMAT (7110/(7E10.3))
  510 READ INPUT TAPE 5,500,INDP,INDR,INDLR,INDLSR,INDS5,INDS6,INDS7,
     1CG1VEH,CG1VEK,(PP(J),J=1,8),((CC(K,I),K=1,5),I=1,KSP1),(HH(J),J=1,5
     2),RN,XL,CGNEAR
      GO TO (520,540,540,520,540),INDR
  520 IF(CG1VEH-Z1S)521,526,523
  521 ALPHA=3.14159266+ATANF(ABSF((Z2S-CG1VEK)/(CG1VEH-Z1S)))
      GO TO 540
  523 ALPHA=ATANF((Z2S-CG1VEK)/(CG1VEH-Z1S))
      GO TO 540
  526 ALPHA=1.57079633
  540 KS=KS+1
      INDFS(KS)=INDF
  545 DO 550 J=1,8
  550 PS(J,KS)=P(J)
      RNS(KS)=RN
```

```
      XLS(KS)=XL
  600 CALL STACLT(2)
  640 IF (KS-1)650,660,700
  650 STOP 650
  660 CALL PRTERR (A,1,LF2,KS)
      IF(A2) 663,675,661
  661 IF(A2-5.0) 675,675,662
  662 CALL CELGE(5,1,1)
      DO 6622 I=1,KS
 6622 C(1,I)=CP(1,I)
      GO TO 675
  663 CALL CELGE(5,1,LF2)
      DO 664 K=1,LF2
      DO 664 I=1,KS
  664 C(K,I)=CP(K,I)
      IF(IK(STR) 667,667,675
  667 DO 668 I=1,KS
  668 C(1,I)=C(L,I)
  675 CALL CLNRFC(2)
  680 SDELTF=DELTAF**1.5
      CALL STACLT(5)
  700 IDEL=1
  800 CALL PRTERR(A,1,LF2,KS)
 1700 CALL PAGEIN
 1900 CALL TIELAT
 2000 DO 2250 K=2,L
      IF(K-2) 2005,2005,2009
 2005 TALP(2)=RS*RHO(12*(A1L*FPUL12+A1T*FPUT1P(2))*DUDP12
      GO TO 2010
 2009 TALP(K)=.5*RS*(RHO(K)*U(K)+RHO(K-1)*U(K-1))*(A1L*.5*(FPUL(K)+FPUL
     1(K-1))+A1T*FPUT1P(K))*(U(K)-U(K-1))/DELTAP
 2010 TALP(K)=.5*RS*(RHO(K+1)*U(K+1)+RHO(K)*U(K))*(A1L*.5*
     1(FPUL(K+1)+FPUL(K))+A1T*FPUT1P(K))*U(K+1)-U(K))/DELTAP
 2250 UM(K)=U(K)-DELTAX*FRF/RHO(K)/U(K)+DELTAX*RS*(TALP(K)-TAUM(K))/DEL
     1TAP
      TALP(1)=FPUL(1)*RS*.5*A1L*A1L2
C     DELCE(1) IS SMALL
 2300 CALL CELGE(1)
 2350 CALL CELGE(3)
 2400 IF(A2) 2500,2415,2410
 2410 CALL BOUTRT(1,LF2)
 2415 DO 2425 K=2,L
      DO 2425 I=1,KS
      IF(I-2) 2416,2416,2418
 2416 IF(C(1,I)) 24164,24162,24164
24162 IF(C(2,I)) 2417,2416,2417
24164 IF(ABSF(C(1,I)-C(2,I))/C(1,I))-.0512416,2417,2417
 2417 DSCR2=2.0*RHOL12*(A3L*FPUL12*(DKDL(K,I)/SCL(K)+DKDL(K-1,I)/SCL(
     1K-1))+A3T*FPUT1P(K)*(DKDT(K,I)/SCT(K)+DKDT(K-1,I)/SCT(K-1)))*DUDP1
     22(I)
      GO TO 2419
 2418 DSCR2=(RHO(K)*U(K)+RHO(K-1)*U(K-1))*(A3L*(FPUL(K)*DKDL(K,I)/SCL(K)
     1+FPUL(K-1)*DKDL(K-1,I)/SCL(K-1))+A3T*FPUT1P(K)*(DKDT(K,I)/SCT(K)+D
     2KDT(K-1,I)/SCT(K-1)))*(C(K,I)-C(K-1,I))/DELTAP
 2419 DSCR1P=.25*RS*((RHO(K+1)*U(K+1)+RHO(K)*U(K))*(A3L*(FPUL(K+1)*DKDL(
     1K+1,I)/SCL(K+1)+FPUL(K)*DKDL(K,I)/SCL(K))+A3T*FPUT1P(K)*(DKDT(K+1,
```

```
     2I)/SCT(N+1)+DKDT(N,I)/SCT(N))(*(C(N+1,I)-C(N,I))/DELTAP-DSCR2)
      IF(A2-5.8) 2424,2624,2420
2420 CM(N,I)=C(N,I)+DELTAX*WCCT(N,I)/RHC(N)/U(N)+DELTAX*RS*DSCRIP/DELTA
     1P
      GO TO 2625
2424 CM(N,I)=C(N,I)+DELTAX*WCCT(N,I)*A2/RHC(N)/U(N)+DELTAX*RS*DSCRIP/D
     1ELTAP
2625 CONTINUE
C     CECLE(I) IS SMALL
      IF(A2-5.8) 243C,243L,242E
2428 CALL CELGE(5,1,1)
      GO TO 2431
243C CALL CELGE(1,C,C)
2431 CALL CELLE(3,C,C)
2500 CALL PSELECT
      IF(A2) 25C1,25C2,25C2
2501 CALL CELGE(5,1,LP2)
2502 IF(JS-2) 2E08,25C5,25C5
2505 IF(IDEL-2) 25C8,256C,256C
250E IF(EPSIP) 251C,251E,251C
2510 IF(ABSF((PHM(L+1(-PHM(L-1())/PHM(L+1()-EPSIP) 2518,2518,2563
2518 IF(EPSIL( 252C,2528,252C
2520 IF(ABSF((UM(L+1(-LM(L-1))/LM(L+1))-EPSIC) 2528,2528,2563
252E IF(A2) 26LE,25<5,2525
2525 IF(EPSIC) 253C,256C,253C
253C DO 254C I=1,5
      IF(ABSF((CM(L+1,I)-CM(L-1,I))/CM(L+1,I))-EPSIC) 2540,254C,2563
254C CONTINUE
256C GO TO 2E0E
2563 PHM(L+3)=PHE
      PRINT 2565,L,UM(L-1(,LM(L+1),(CM(L-1,I),I=1,5),(CM(L+1,I),I=1,5),
     1PHM(L-1),PHM(L+1)
2565 FORMAT(4F  L=I3,1P7E13.5/1P7E13.5(
      CALL LCSTRE
      L=L+1
      LP2=LP2+1
      UM(L-4)=U(L-4)/U(L-I(*LM(LP2)
      UM(L-3)=U(L-3)/U(L-1)*LM(LP2)
      UM(L-2)=U(L-2(/U(L-1)*LM(LP2)
      LM(L-1)=LM(LP2(
      CM(L)=LM(LP2)
      LM(L+1(=LM(LP2)
      IF(EPSIC) 2567,256E,2567
2567 DO 257C I=1,NS
      CM(L-4,(=L(L-4,I)/C(L-1,I)*CM(LP2,(
      CM(L-3,()=C(L-3,I(/C(L-1,I)*CM(LP2,I)
      CM(L-2,()=C(L-2,I)/C(L-1,I(*CM(LP2,()
      CM(L-1,I)=LM(LP2,()
      CM(L,I)=LM(LP2,I)
257C CM(L+1,I)=CM(LP2,()
      GO TO 2573
2568 DO 2569 (=1,NS
      CM(L,I)=CM(LP2,I(
2569 CM(L+1,I)=LM(LP2,()
2573 CALL LCNPRG(3)
      IF(LP2-99) 26C0,2575,2575
```

```
2575 STOP 2575
2600 DO 2604 N=1,LP2
     L(N)=LP(N)
     DO 2602 I=1,NS
2602 C(N,I)=CP(N,I)
2604 FH(N)=FFP(N)
     CALL STACLT(9)
     X=X+DELTAX
     RS=RSP
     GO TO 2650
2606 CALL STEPS2
2610 IF(INDSTP-2)700,600,2700
2650 IF(L+1-2*LCRIG)2700,2660,2655
2655 STOP 2655
2660 DO 2670 N=2,LCRP1
     N2=2*N-1
     L(N)=L(N2)
     DO 2665 I=1,NS
2665 C(N,I)=C(N2,I)
     FH(N)=FF(N2)
     PSI(N)=PSI(N2)
2670 Y(N)=Y(N2)
     L=LCRIG
     LP2=L+2
     L(LP2)=L(LCRP1)
     DO 2675 I=1,NS
2675 C(LP2,I)=C(LCRP1,I)
     FH(LP2)=FH(LCRP1)
     DELTAP=2.0*DELTAF
     PSI(LP2)=PSI(LCRP1)+DELTAF
     CALL CCNPRG(3)
2680 PRINT 2685,JS
2685 FORMAT(21H  NO PSI PTS 1/2  JS=I6)
2700 IF(INDFSU)2750,2750,3000
2750 IF(X-XL)2755,2775,2900
2755 IF(SENSE SWITCH 4)2760,700
2760 PUNCH 2761,KS,(INDPS(N),N=1,KS),L,LP2,INDFSU,INDP,INDR,INDLR,INDLS
    1R
2761 FORMAT(1415)
2763 PUNCH 2765,X,DELTAX, (L(N),N=1,LP2),
    1 (((C(N,I),N=1,LP2),I=1,NS),(FH(N) ,N=1,LP2),(PSI(N),N=1,LP2),
    2DELTAP,(Y(N),N=1,LP2),Z1,Z2,Z1S,Z2S,CGIVEH,CGIVEK,(P(J),J=1,8),
    3(((CC(M,I),K=1,5),I=1,NS),(HP(J),J=1,5),RN,XL,CONEAN,((PS(J,I),J=1,
    48),I=1,KS),(RAS(N),N=1,KS),(XLS(N),N=1,KS),ALPHA,XS,RS,RSM
     GO TO 3030
2765 FORMAT(6C12)
2775 DELTXS=DELTAX
2800 INDFSU=1
     GO TO 700
2900 DELTXS=DELTAX
     DELTAX=DELTAX-(X-XL)
     X=X-DELTXS+DELTAX
     GO TO 2800
3000 IF(INDLSR)3100,3100,3020
3020 IF(INDLR) 3100,3100,3030
3030 X=X-DELTAX
```

```
      CALL STACLT(9)
      CALL EXIT
3100  Z1S=Z1
      Z2S=Z2
      X=X-DELTA
      CALL STACLT(9)
      X=X+DELTXS
3150  INLPSW=0
      DELTAX=DELTXS
      GO TO 310
5000  FORMAT(12A6)
5001  FORMAT(1H1,43X,31HCENERAL  APPLIED  SCIENCE  LABS///)
5002  FORMAT(1H0,21X,77HMINIMUM  DIFFERENCE  SOLUTION  OF  CHEMICALLY  REAC
     1TING  AIR  BOUNDARY  LAYERS///)
5003  FORMAT(/1H ,12A6//1H ,12A6//1H ,12A6/)
      END(1,1,0,0,0,0,0,1,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

	DEC	OCT
	2117	04105

	DEC	OCT
	23203	55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT
A1L	32561	77461
A4L	32556	77454
AB1T	32552	77450
AB6T	32547	77443
ASR	32533	77425
B4T	32342	77126
BB2T	32101	76545
BB7T	32096	76540
BDI2	32014	76416
CM1	30143	72677
CP	29532	71534
DCDP12	28920	70370
DELXST	28906	70352
DN2DL2	27702	66066
DUDP12	27696	66062
EPSIT	27634	65762
FC	27629	65755
FMCALC	27564	65654
FMS	27383	65367
FLETIN	27259	65173
FLNC	27076	64706
FMUL	26888	64410
FNUREW	23215	55257
FSM1	26044	64024
FSKRC	26012	62634
FSK	26033	62661
FSMC	25985	62601
IDEL	25976	62570
INDPS	25953	62541
IPRINT	23213	55255
LP2	25886	62436
NS	25884	62434
PRAL	25870	62416
PRP	25687	62127
PSI	25225	61211
RETHET	23219	55263
RMCE	25041	60721
RNS	25037	60715
SCHLIN	24984	60630
SIGMAC	24861	60435
STRLL	23206	55246
THETAT	24499	57663
TITLE3	24472	57630
TVNO	24399	57517
UINF	24274	57322
U	24396	57514
XLS	23429	55605
Y12	23262	55250

	DEC	OCT
A1T	32560	77460
A4T	32555	77453
AL2T	32551	77447
AB7T	32546	77442
AL12	32523	77413
B5T	32262	77032
BB3T	32100	76544
BC12	32095	76537
C12	31413	75265
CM2	30133	72665
C	32013	76415
DEL	28910	70356
DMDP12	28905	70351
DN2	27703	66067
EDELS	27697	66061
EPS	27633	65761
FLDA	27626	65754
FPE	27504	65500
FRC	27323	65273
FLEWL	27256	65172
FLL2	26956	64514
FMLTIM	26827	64313
FNUREY	23216	55260
FSHE	26034	62602
FSKRD	26002	62622
FSME	25989	62605
GAMA	25984	62600
INDCOO	25975	62567
INDR	25903	62457
JBYCTR	23211	55253
L	25887	62437
CGIVEN	25882	62432
PRATIN	25749	62225
PR	25671	62417
PSITOL	25165	61115
REW	23217	55261
RMC	25161	61111
S	25163	61113
SCHTIN	24983	60627
SIGMAH	24801	60341
T12	23205	55251
THFER	24498	57662
TM	24460	57614
TVD2	24397	57515
ULCLIM	24273	57321
US	24092	57034
XRN	23379	55523
YCALC	23316	55424

	DEC	OCT
A2	32559	77457
A5L	32554	77452
AB3T	32550	77446
AC12	32545	77441
B1T	32522	77412
B6T	32222	76736
BB4T	32099	76543
BM12	32065	76525
CCALC	31353	75171
CM	30743	74027
CSR	28930	70402
DELTAP	28909	70355
DIST	28904	70350
DRC	27701	66065
EPSIC	27636	65764
ETA	27632	65760
FELB	27627	65753
FHM2	27443	65463
FKPSI	27321	65271
FLEWT	27198	65076
FL	27261	65175
FMLTIP	26767	64217
FSM12	23210	55252
FSP	26705	64121
FSKRE	26001	62621
FSMNCP	25986	62602
HE	25983	62577
INDLAS	25965	62555
INDSTP	25902	62456
JINPLT	25890	62442
KCOUNT	23212	55254
CGIVEK	25881	62431
PRAT	25809	62321
PRSAVE	25686	62126
PS	25685	62125
REX	23218	55262
RMCSTG	25039	60717
RSC	24966	60632
SCL	24982	60626
SIGMAU	24741	60245
TALM	24620	60054
TIN	24497	57661
T	24680	60150
U12	24336	57420
UM1	24212	57224
UDOT	24032	56740
X	23432	55610
Y	23376	55520

	DEC	OCT
A3L	32558	77456
A5T	32553	77451
AB4T	32549	77445
AH12	32535	77427
B2T	32462	77316
BB1T	32102	76546
BB6T	32097	76541
BLOCK	32084	76524
BSR	32024	76430
CC	31403	75253
CONEAN	29533	71535
CS	29530	71532
DELTAX	28908	70354
DKDL	28903	70347
DO2	27700	66064
EPSIH	27635	65763
FA	27631	65757
FEDC	27626	65752
FHM	27503	65557
FKPSI	27322	65272
FLN2	27138	65002
FM	26898	64422
FNDSSH	26707	64123
FSHE	26645	64025
FSKRA	26032	62660
FSKRF	26000	62620
FSMN	25988	62604
HH	25982	62576
INDPRI	25954	62542
INDTYP	25900	62454
NPSI	25885	62435
PRDIRA	25748	62224
P	25880	62430
RHO12	25040	60720
RN	25038	60716
RSM	24985	60631
SCT	24922	60532
STRLL	23207	55247
TAUP	24560	57760
TITLE1	24496	57660
TVN2	24400	57520
UCALC	24335	57417
UM2	24152	57130
XI	23431	55607
XS	23378	55522
YTHC	23255	55327

	DEC	OCT
A3T	32557	77455
AAU	23204	55244
AB5T	32548	77444
ALPHA	32534	77426
B3T	32402	77222
BB1T	32102	76546
BB6T	32097	76541
BSR	32024	76430
CE	30753	74041
CPE	29531	71533
CSUB	23214	55256
DELXOD	28907	70353
DKDT	28303	67217
DSCRIP	27699	66063
EPSI	27637	65765
FB	27630	65756
FH12	27565	65655
FH	27625	65751
FLELIN	27260	65174
FLNDP	27018	64612
FMUL12	26828	64314
FNDSSL	26706	64122
FSH112	26044	62674
FSKRB	26022	62646
FSKRK	25999	62617
FSMN	25988	62604
IALT	25977	62571
INDP	25955	62543
INDTYP	25900	62454
KS	25888	62440
NSR	25883	62433
PRALIN	25910	62322
PRDS	25688	62130
PSCALC	25285	61305
RESTAR	25162	61112
RHOCAL	25101	61015
RN	25038	60716
RS	24987	60633
SHANGL	24862	60436
STRLL	23207	55247
TESTRA	24500	57664
TITLE2	24484	57644
TVNDP	24398	57516
UE	24275	57323
UM	24272	57320
XL	23430	55606
XU12	23377	55521
YTH	23256	55330

YTHU	23245	55315	Z1L	23243	55313	Z1R	23242	55312	Z1	23244	55314	Z1S	23232	55300
Z2R	23230	55276	Z2	23231	55277	Z2S	23220	55264						

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
DELTXS	2116	04104	LSCRA	2115	04103	INDFSU	2114	04102	INDLR	2113	04101	INDLSR	2112	04100
INDS5	2111	04077	INDS6	2110	04076	INDS7	2109	04075	1	2108	04074	LORZG	2107	04073
LORP1	2106	04072	N2	2105	04071	N	2104	04070	NSM1	2103	04067	SDELTP	2102	04066
SLOPE1	2101	04065	SLOPE2	2100	04064									

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
812	2	04031	815	5	04024	81P	25	04022	81FK	500	04015	81265	2565	04012
812JT	2685	04005	812M9	2761	04000	812MD	2765	03777	814S8	5000	03776	814S9	5001	03775
814SA	5002	03765	814SE	5003	03746									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
11	2074	04032	21	1590	03706	31	2002	03722	41	32767	77777	61	2012	03734
C1GC	2085	04045	C1G1	2086	04046	C1G3	2087	04047	C1G5	2088	04050	C1G6	2089	04051
C1G7	2090	04052	C1G8	2091	04053	C1G9	2092	04054	C1100	2093	04055	C1102	2094	04056
C1106	2095	04057	C1107	2096	04060	C1109	2097	04061	C1200	2098	04062	C1205	2099	04063
D1245	1233	02321	D1246	1290	02412	D1345	1232	02320	D140M	353	00541	D143Q	1055	02037
D1444	1225	02311	D144F	1461	02665	D144R	1472	02700	D1454	1507	02743	D145Q	1688	03230
D1656	1667	03227	E1U	342	00526	E10	363	00553	E112	460	00714	E113	466	00722
E117	496	00760	E119	522	01012	E11C	587	01113	E13D	993	01741	E14A	1289	02411
E150	1498	02732	E1IOF	366	00560	E113R	1067	02053	E114A	1289	02411	E143P	1052	02034

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ATAN	10	00012	CELGE	12	00014	CONPRG	7	00007	EXIT	23	00027	EXP(3	13	00015
HSCLUT	18	00022	PRTERH	11	00013	RADBLY	14	00016	SQRT	8	00010	STAOUT	9	00011
STEPSZ	21	00025	UCSTRE	20	00024	UEDGE	16	00020	VISLAT	15	00017	WDOTRT	17	00021
(FIL)	5	00005	(FPT)	0	00000	(RTN)	3	00003	(SCH)	22	00026	(SLI)	2	00002
(SLO)	6	00006	(SPH)	19	00023	(STH)	4	00004	(TSH)	1	00001			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ATAN	CELGE	CONPRG	EXIT	EXP(3	HSCLUT	PRTERH	RADBLY	SQRT	STAOUT
STEPSZ	UCSTRE	UEDGE	VISLAT	WDOTRT	(FIL)	(FPT)	(RTN)	(SCH)	(SLI)
(SLO)	(SPH)	(STH)	(TSH)						

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
1	21	00044	9	70	00500	11	72	00507	13	75	00530	15	76	00534
16	77	00542	17	80	00551	18	81	00555	19	82	00562	20	83	00566
30	90	00640	32	94	00670	63	95	00673	65	96	00676	68	97	00702
70	98	00707	75	99	00715	76	100	00723	78	102	00731	81	103	00733
82	105	00745	84	107	00761	85	109	00777	87	111	01013	88	115	01031
89	116	01043	90	120	01114	91	121	01121	92	122	01125	94	124	01132

99	126	01145	100	128	01152	175	129	01156	180	135	01223	210	185	01451
300	186	01459	305	187	01457	310	188	01462	315	189	01464	325	190	01470
335	191	01474	345	192	01500	355	193	C15C4	365	194	01510	375	195	01514
400	196	01520	510	197	01523	520	213	01622	521	214	01626	523	216	01645
526	216	01662	540	219	01664	545	221	01672	550	222	01704	600	225	01715
640	226	01717	650	227	01723	660	228	C1725	661	230	01742	662	231	01747
6622	233	01762	663	235	01767	664	238	C2C1C	667	240	02022	668	241	02026
675	242	C2035	680	243	C2040	700	245	C2054	800	246	02056	1700	247	02067
1900	248	C2071	2000	249	02073	2009	251	C2104	2009	253	02123	2010	254	02161
2250	255	C2217	2300	257	C2254	2350	258	02257	2400	259	02262	2410	260	02266
2415	261	C2275	2416	264	C2326	24162	265	C2332	24164	266	02336	2417	267	02347
2418	268	C2413	2419	270	C2463	2420	272	02545	2424	274	02564	2425	275	02601
2428	277	C2623	2430	279	C2630	2431	280	02634	2500	281	02640	2501	283	02644
2502	284	C2651	2505	285	02657	2508	286	C2663	2510	287	02666	2518	288	02676
2520	289	C2701	2528	290	C2711	2529	291	C2715	2550	292	02717	2540	294	02737
2560	295	C2742	2563	296	C2744	2567	316	03044	2570	322	03071	2568	324	03100
2569	326	C3107	2573	327	C3115	2575	329	03124	2600	330	03126	2602	333	03144
2604	334	C3151	2608	339	C3166	2610	340	03167	2650	341	03174	2655	342	03205
2660	343	C3207	2665	347	C3243	2670	350	03256	2675	355	03311	2680	360	03334
2700	362	C3344	2750	363	03347	2755	364	C3353	2760	365	03355	2763	371	03407
2775	420	C3626	2800	421	C3630	2900	423	03633	3000	427	03647	3020	428	03653
3030	429	C3657	3100	432	C3665	3150	437	03701						

```
      SUBROUTINE CEDGE(J,NSTART,NEND)

      SUBROUTINE CEDGE(J,NSTART,NEND)
C
      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
     4CSR,DCDP12,DEL,DELTAP,DELTAX,DELXDD,DELXST,DHDP12,DIST,DKDL,
     5DKDT,DN2,DN2DD2,DNO,DO2,DSCRIP,DUDP12,EDENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
     7FEDC,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
      COMMON FINO,FK,FKPSI,FL,FLELIM,FLETIN,FLEWL,FLEWT,
     1FLN2,FLNO,FLNOP,FLO2,FM,FMUL,FMUL12,FMUTIM,FMUTIP,FNDSSH,
     2FNDSSL,FSH,FSHE,FSHI,FSHI12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMNO,FSMNOP,FSMO,GAMM,HE,
     4HH,IALT,IDEL,INDCDO,INDLAS,INDP,INDPRI,INDPS,INDR,
     5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     6OGIVEN,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
      COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVNO,TVNOP,TVO2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
     6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
C
      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
     4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
     5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLNO(60),
     6FLNOP(60),FLO2(60),FM(10),FMUL(60),FMUTIM(60)
      DIMENSION FMUTIP(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCDO(10),
     2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)
      DIMENSION ROOTT(60)
C
C     CEDGE(1) IS CWALL
C     CEDGE 9 IS EQUILIBRIUM SPECIES CALCULATION
C
      J=J
      NSTART=NSTART
      NEND=NEND
      IF(J-9) 40,1000,1000
   40 SUMCW=0.0
      IF(J-1) 79,50,80
   50 DO 55 I=1,6
```

```
      SUBROUTINE CEDGE(J,NSTART,NEND)
   55 CM(1,I)=CC(1,I)+CC(2,I)*XRN+CC(3,I)*XRN**2+CC(4,I)*XRN**3+CC(5,I)*
     1XRN**4
      CM(1,7)=FM(7)/FM(6)*CM(1,6)
      DO 62 I=1,NS
      IF(CM(1,I)) 70,60,60
   60 IF(CM(1,I)-1.01) 62,62,70
   62 CONTINUE
   63 DO 65 I=1,NS
   65 SUMCW=SUMCW+CM(1,I)
      IF(SUMCW-1.001) 67,78,70
   67 IF(SUMCW-.999) 70,78,78
   70 PRINT 72,(CM(1,I),I=1,NS),SUMCW
      STOP 71
   72 FORMAT(4E13.4/4E13.4)
   78 RETURN
   79 STOP 60
   80 IF(J-3) 90,200,300
   90 DO 100 I=1,NS
  100 CM(L,I)=WDOT(L,I)*DELTAX/RHO(L)/U(L)+C(L,I)
      RETURN
  200 DO 250 I=1,NS
  250 CM(L+1,I)=WDOT(L+1,I)*DELTAX/RHO(L+1)/U(L+1)+C(L+1,I)
  300 DO 350 I=1,NS
  350 CM(L+2,I)=WDOT(L+2,I)*DELTAX/RHO(L+2)/U(L+2)+C(L+2,I)
      RETURN
 1000 DO 1150 I=NSTART,NEND
      ROOTT(I)=SQRTF(T(I))
      B1=1.+.66667*EXPF(-11390.772/T(I))+EXPF(-18984.62/T(I))/3.
      B4=1.+.6*EXPF(-228./T(I))+.2*EXPF(-326./T(I))
      E4=1.+EXPF(-178./T(I))
      B5=1.+2.5*EXPF(-27698.424/T(I))+1.5*EXPF(-41520.32/T(I))
      E1=1.-EXPF(-2274./T(I))
      E2=1.-EXPF(-3395./T(I))
      E3=1.-EXPF(-2740./T(I))
      SF1=908.18699*ROOTT(I)*T(I)*T(I)*B1/E1
      SF2=178.39387*ROOTT(I)*T(I)*T(I)/E2
      SF3=934.13519*ROOTT(I)*T(I)*T(I)*E4*EXPF(-11062.98/T(I))/E3
      SF4=2237.1532*T(I)*ROOTT(I)*B4*EXPF(-29501.28/T(I))
      SF5=1461.9021*T(I)*ROOTT(I)*B5*EXPF(-56544.12/T(I))
      SF6=SQRTF(SF4*SF5)
      BBAR=0.0
      DO 1130 M=1,20
      BTERM=SF4*1.E-6+BBAR*SF3*1.E-12
      AC=SF1*RHO(I)*1338.7286E-12
      ABAR=(-BTERM+SQRTF(BTERM*BTERM+AC))/(SF1*4.E-12)
      BTERM=SF5*1.E-6+ABAR*SF3*1.E-12
      AC=SF2*RHO(I)*5060.8388E-12
      BBAR1=(-BTERM+SQRTF(BTERM*BTERM+AC))/(4.E-12*SF2)
      IF(ABSF(BBAR1-BBAR)-.00001)1120,1130,1130
 1130 BBAR=BBAR1
      PRINT 1300
 1300 FORMAT(40HIALPHA BAR AND BETA BAR DID NOT CONVERGE)
      CALL EXIT
 1120 BBAR=BBAR1
      CM(I,1)=SF1*ABAR*ABAR*2.77278E-15/RHO(I)
      CM(I,3)=SF2*BBAR*BBAR*2.428056E-15/RHO(I)
```

```
      CM(I,5)=SF3*ABAR*BBAR*2.600418E-15/RHO(I)
      CM(I,2)=SF4*ABAR*1.38639E-9/RHO(I)
      CM(I,4)=SF5*BBAR*1.214028E-9/RHO(I)
      E12=EXPF((-32125.131/T(I)))
      Q=.1596622TE-11*T(I)*E12/E2/84
      ENOP=SQRTF(Q)*SQRTF(CM(I,2))*SQRTF(CM(I,4))
      CM(I,6)=ENOP*233.902493
      CM(I,7)=ENOP/233.902493
1150  CONTINUE
      RETURN
      END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
725	01325	23210	55252

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	AB1T	32552	77450
AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	AB5T	32548	77444	AB6T	32547	77443
AB7T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426	ASR	32533	77425
AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222	B4T	32342	77126
B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	BB1T	32102	76546	BB2T	32101	76545
BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541	BB7T	32096	76540
BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430	BU12	32014	76416
C12	31413	75265	CC	31403	75253	CE	30753	74041	CM1	30143	72677	CM2	30133	72665
CONEAN	29533	71535	CP	29532	71534	CPE	29531	71533	CS	29530	71532	CSR	28930	70402
CSUB	23214	55256	DCDP12	28920	70370	DELTAP	28909	70355	DELTAX	28908	70354	DELXOD	28907	70353
DELXST	28906	70352	DIST	28904	70350	DKDL	28903	70347	DKDT	28303	67217	DN	27700	66064
DN2	27703	66067	DN2D02	27702	66066	DNO	27701	66065	DOUDP12	27698	66062	DQ2	27700	66064
EDENS	27697	66061	EPSI	27637	65765	EPSIC	27636	65764	EPSIH	27635	65763	EPSIT	27634	65762
EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757	FB	27630	65756	FC	27629	65755
FEDA	27628	65754	FEDB	27627	65753	FEDC	27626	65752	FH12	27565	65655	FHCALC	27564	65654
FHE	27504	65560	FHM	27503	65557	FH	27625	65751	FHS	27383	65367	FHM2	27443	65463
FINO	27323	65273	FK	27322	65272	FKPSI	27321	65271	FLELIN	27260	65174	FLETIN	27259	65173
FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002	FLNOP	27018	64612	FLNO	27078	64706
FLO2	26958	64516	FL	27261	65175	FM	26898	64422	FMUL12	26828	64314	FMUL	26888	64410
FMUTIM	26827	64313	FMUTIP	26767	64217	FNDSSH	26707	64123	FNDSSL	26706	64122	FNUREW	23215	55257
FNUREX	23216	55260	FSHI	26644	64024	FSHI12	26044	62674	FSHP	26034	62662	FSHE	26045	64025
FSH	26705	64121	FSKRC	26012	62634	FSKRA	26032	62660	FSKRB	26022	62646	FSKRD	26002	62622
FSKRE	26001	62621	FSK	26033	62661	FSKRF	26000	62620	FSKRK	25999	62617	FSME	25989	62605
FSMNOP	25986	62602	FSMO	25985	62601	FSMNO	25987	62603	FSMN	25988	62604	GAMM	25984	62600
HE	25983	62577	IDEL	25976	62570	HH	25982	62576	IALT	25977	62571	INDCOO	25975	62567
INDLAS	25965	62555	INDR	25903	62457	INDPRI	25954	62542	INDP	25955	62543	INDPS	25953	62541
INDSTP	25902	62456	JBYCTR	23211	55253	INDSTR	25901	62455	INDTYP	25900	62454	IPRINT	23213	55255
JINPUT	25890	62442	L	25887	62437	JS	25889	62441	KS	25888	62440	LP2	25886	62436
NCOUNT	23212	55254	OGIVEH	25882	62432	NPSI	25885	62435	NSR	25883	62433	NS	25884	62434
OGIVEK	25881	62431	PRATIN	25749	62225	PE	25872	62420	PRALIN	25810	62322	PRAL	25870	62416
PRAT	25809	62321	PR	25871	62417	PRDIRA	25748	62224	PROS	25688	62130	PRP	25687	62127
PRSAVE	25686	62126	PSITCU	25165	61115	P	25880	62430	PSCALC	25285	61305	PSI	25225	61211
PS	25685	62125	REW	23217	55261	QW	25164	61114	RESTAR	25162	61112	RETHET	23219	55263
REX	23218	55262	RHO	25161	61111	RHO12	25040	60720	RHOCAL	25101	61015	RHOE	25041	60721
RHOSTG	25039	60717	RSC	24986	60632	RN	25038	60716	RNS	25037	60715	R	25163	61113
RSM	24985	60631	SCL	24982	60626	RS	24987	60633	SCHLIN	24984	60630	SCHTIN	24983	60627
SCT	24922	60532	SIGMAU	24741	60245	SHANGL	24862	60436	SIGMAC	24861	60435	SIGMAH	24801	60341
STADIS	24681	60151	THETAT	24499	57663	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664
THPER	24498	57662	TITLE3	24472	57630	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644
TM	24460	57614	TVNO	24399	57517	T	24680	60150	TVN2	24400	57520	TVNOP	24398	57516
TW02	24397	57515	UINF	24274	57322	U12	24336	57420	UCALC	24335	57417	UE	24275	57323
ULOLIM	24273	57321	U	24396	57514	UM1	24212	57224	UM2	24152	57130	UM	24272	57320
US	24092	57034	XLS	23429	55605	WDOT	24032	56740	XI	23431	55607	XL	23430	55606
XRS	23379	55523	YCALC	23316	55424	X	23432	55610	XS	23378	55522	XU12	23377	55521
Y	23376	55520	Z1L	23243	55313	YTHC	23255	55327	YTH	23256	55330	YTHU	23245	55315
Z1R	23242	55312	Z2	23231	55277	Z1	23244	55314	Z1S	23232	55300	Z2R	23230	55276
Z2S	23229	55264												

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ROOTT	724	01324												

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ABAR	664	01230	AC	663	01227	B1	662	01226	B4	661	01225	B5	660	01224
BBAR1	659	01223	BBAR	658	01222	BTERM	657	01221	E12	656	01220	E1	655	01217
E2	654	01216	E3	653	01215	E4	652	01214	ENOP	651	01213	I	650	01212
K	649	01211	Q	648	01210	SF1	647	01207	SF2	646	01206	SF3	645	01205
SF4	644	01204	SF5	643	01203	SF6	642	01202	SUMCW	641	01201			

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8128	72	01161	8)18K	1300	01156									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	626	01162	2)	561	01061	3)	567	01067	6)	609	01141	C)G1	633	01171
C)G2	634	01172	C)100	635	01173	C)103	636	01174	C)104	637	01175	C)200	638	01176
C)202	639	01177	C)204	640	01200	D)213	480	00740	D)40E	129	00201	E)8	103	00147
E)1[illegible]	464	00720	E)12	472	00730									

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXIT	4	00004	EXP	3	00003	SQRT	2	00002	(FIL)	1	00001	(SPH)	0	00000

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXIT EXP SQRT (FIL) (SPH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
49	17	00051	50	19	00060	55	20	00062	60	24	00142	62	25	00154
63	26	00157	65	27	00164	67	29	00175	70	30	00202	78	36	00226
79	38	00232	80	39	00234	90	40	00240	100	41	00244	200	44	00262
250	45	00270	300	46	00302	350	47	00306	1000	50	00324	1130	74	00724
112	77	00741	1150	88	01052									

```
      SUBROUTINE CONPRG(K)

      SUBROUTINE CONPRG(K)
C
      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
     4CSR,DCDP12,DEL,DELTAP,DELTAX,DELXOD,DELXST,DHDP12,DIST,DKDL,
     5DKDT,DN2,DN2DO2,DNO,DO2,DSCRIP,DUDP12,EDENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
     7FEDC,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
      COMMON FINO,FK,FKPSI,FL,FLELIN,FLETIN,FLEWL,FLEWT,
     1FLN2,FLNO,FLNOP,FLO2,FM,FMUL,FMUL12,FMUT1M,FMUT1P,FNDSSH,
     2FNDSSL,FSH,FSHE,FSHI,FSHI12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMNO,FSMNOP,FSMO,GAMM,HE,
     4HH,IALT,IDEL,INDCOO,INDLAS,INDP,INDPRI,INDPS,INDR,
     5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     6OGIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
      COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVNO,TVNOP,TVO2,U,UI2,UCALC,UE,UINF,ULOLIM,UM,UM1,
     6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
     1,FSH12,T12,Y12,STRLL,STRUL,RHOU12,AAU,EHP,FSK15,
     2FSMO15,FSMN15,FSME5
C
      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
     4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
     5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLNO(60),
     6FLNOP(60),FLO2(60),FM(10),FMUL(60),FMUT1M(60)
      DIMENSION FMUT1P(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCOO(10),
     2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)
C
      K=K
      IF(K-9) 100,3000,3000
  100 IF(K-2) 120,600,2200
C     PROGRAM CONSTANTS FOR MOMENTUM EQUATION
  120 CP=14000.
      DO2=5.1155
      DN2=9.7592
      DNO=6.5060
      DN2DO2=.5*(DN2+DO2)-DNO
```

```
      FINO=9.250
      FM(1)=32.000
      FM(2)=16.000
      FM(3)=28.016
      FM(4)=14.008
      FM(5)=30.008
      FM(6)=30.008
      FM(7)=5.4862E-4
      FSMO=2.6556E-23
      FSMN=2.3249E-23
      FSMNO=4.9805E-23
      FSME=9.1056E-28
      FSMNOP=FSMNO-FSME
      R=8.95805E4
      TVN2=3395.0
      TVNO=2740.0
      TVNOP=3395.0
      TVO2=3274.0
C
C     PROGRAM CONSTANTS FOR SPECIES EQUATION
  140 ETA=6.0251E23
      FSHP=4.8247E-34
      FSK=1.01794E-23
      FSKRE=2.7E-11
      EHP=ETA*FSHP
      FSK15=FSK**1.5/FSHP
      FSMO15=FSMO**1.5/FSHP
      FSMN15=FSMN**1.5/FSHP
      FSME5=SQRTF(FSME)/FSHP
C
C     SCHMIDT AND DIFFUSION COEF RATIOS FOR SPECIES EQS
      DO 145 N=1,60
      SCL(N)=SCHLIN
      SCT(N)=SCHTIN
      DKOL(N,1)=1.0
      DKOL(N,2)=1.0
      DKOL(N,3)=1.0
      DKOL(N,4)=1.0
      DKOL(N,5)=1.0
      DKOL(N,6)=1.0
      DKOL(N,7)=1.0
      DKOT(N,1)=1.0
      DKOT(N,2)=1.0
      DKOT(N,3)=1.0
      DKOT(N,4)=1.0
      DKOT(N,5)=1.0
      DKOT(N,6)=1.0
      DKOT(N,7)=1.0
C
C     PRANDTL AND LEWIS NOS FOR ENERGY EQ
      PRAL(N)=PRALIN
      PRAT(N)=PRATIN
      FLEWL(N)=FLELIN
  145 FLEWT(N)=FLETIN
      RETURN
  600 END
```

```
      RHOCAL(1)=RHO(1)
      PSI(1)=0.0
      DO 700 N=2,L
  700 PSI(N)=PSI(N-1)+.5*(Y(N)-Y(N-1))*RS*(RHO(N)*U(N)+RHO(N-1)*U(N-1))
      DELTAP=(PSI(L)-PSI(1))/(FN-1.0)
      DO 800 N=1,LP2
      WRITE OUTPUT TAPE 6,750,N,PSI(N)
  750 FORMAT(5XI3,3X1PE13.5)
      FN=N
  800 PSCALC(N)=(FN-1.0)*DELTAP
  910 J=2
  920 DO 1400 N=2,L
  950 IF(PSCALC(N)-PSI(J))1300,1200,1000
 1000 J=J+1
      IF(J-L)950,950,1010
 1010 J=J-1
 1200 UCALC(N)=U(J)
      DO 1250 I=1,NS
 1250 CCALC(N,I)=C(J,I)
      FHCALC(N)=FH(J)
      RHOCAL(N)=RHO(J)
      GO TO 1400
 1300 PFACTR=(PSCALC(N)-PSI(J-1))/(PSI(J)-PSI(J-1))
      UCALC(N)=U(J-1)+PFACTR*(U(J)-U(J-1))
      DO 1310 I=1,NS
 1310 CCALC(N,I)=C(J-1,I)+PFACTR*(C(J,I)-C(J-1,I))
      FHCALC(N)=FH(J-1)+PFACTR*(FH(J)-FH(J-1))
      RHOCAL(N)=RHO(J-1)+PFACTR*(RHO(J)-RHO(J-1))
 1400 CONTINUE
      UCALC(L+1)=UCALC(L)
      UCALC(L+2)=UCALC(L)
      DO 1450 I=1,NS
      CCALC(L+1,I)=CCALC(L,I)
 1450 CCALC(L+2,I)=CCALC(L,I)
      FHCALC(L+1)=FHCALC(L)
      FHCALC(L+2)=FHCALC(L)
      RHOCAL(L+1)=RHOCAL(L)
      RHOCAL(L+2)=RHOCAL(L)
      YCALC(1)=0.0
 1470 DEL12=SQRTF(DELTAP)
      DELH12=.707107*DEL12
      AU12=(2.0*UCALC(2)-UCALC(3))/.58579/DEL12
      BU12=(UCALC(3)-1.41421*UCALC(2))/.58579/DELTAP
      U12=AU12*DELH12+BU12*.5*DELTAP
      DUDP12=.5*AU12/DELH12+BU12
      AAU=(2.0*RHOCAL(2)*UCALC(2)-RHOCAL(3)*UCALC(3))/DEL12/.58579
      BBU=(RHOCAL(3)*UCALC(3)-1.4142*RHOCAL(2)*UCALC(2))/DELTAP/.58579
      YCALC(2)=2.0/BBU/RS*LOGF(1.0+BBU/AAU*DEL12)
      PRINT 1510,RHOCAL(2),RHOCAL(3),RS,DELTAP,UCALC(2),UCALC(3),DUDP12
     1,AAU,BBU,YCALC(2),U12
 1510 FORMAT(3X1P6E13.5/8X1P5E13.5)
 1650 DO 1900 N=3,LP2
 1900 YCALC(N)=YCALC(N-1)+.5*(PSCALC(N)-PSCALC(N-1))/RS*(1.0/(RHOCAL(N)*
     1UCALC(N))+1.0/(RHOCAL(N-1)*UCALC(N-1)))
      IF(ABSF((YCALC(L)-Y(L))/Y(L))-.001) 1910,1910,1905
 1905 PRINT 1906, YCALC(L),Y(L)
```

```
 1906 FORMAT(1H 9HYCALC(L)=1PE13.6,5HY(L)=1PE13.6)
 1910 DO 2000 N=2,LP2
      Y(N)=YCALC(N)
      U(N)=UCALC(N)
      FH(N)=FHCALC(N)
      RHO(N)=RHOCAL(N)
      PSI(N)=PSCALC(N)
      DO 2000 I=1,NS
 2000 C(N,I)=CCALC(N,I)
C     PSI PROFILES FOR MOMENTUM EQUATION
 2200 SUMDP=0.0
      DO 2500 N=1,LP2
      FKPSI(N)=FA+FB*SUMDP+FC*SUMDP**2
      IF(SUMDP/PSI(L)-TESTRA) 2300,2300,2310
 2300 B1T(N)=AB1T
      B2T(N)=AB2T
      B3T(N)=AB3T
      B4T(N)=AB4T
      B5T(N)=AB5T
      B6T(N)=AB6T
      B7T(N)=AB7T
      GO TO 2500
 2310 B1T(N)=BB1T
      B2T(N)=BB2T
      B3T(N)=BB3T
      B4T(N)=BB4T
      B5T(N)=BB5T
      B6T(N)=BB6T
      B7T(N)=BB7T
 2500 SUMDP=SUMDP+DELTAP
      RETURN
 3000 IF(THPER-1.0) 3001,3009,3001
 3001 IF(BLOCK(L-1)-BLOCK(L+1)) 3101,3005,3201
 3005 IF(BLOCK(L-2)-BLOCK(L+1)) 3101,3009,3201
 3009 YTH=Y(L)
      GO TO 3301
 3101 DO 3109 N=1,L
      LP1MN=L+1-N
      LP2MN=LP1MN+1
      IF(THPER*BLOCK(L+1)-BLOCK(LP1MN)) 3109,3115,3119
 3109 CONTINUE
 3111 GO TO 3009
 3115 YTH=Y(LP1MN)
      GO TO 3301
 3119 YTH=Y(LP1MN)+(THPER*BLOCK(L+1)-BLOCK(LP1MN))*(Y(LP2MN)-Y(LP1MN))/
     1(BLOCK(LP2MN)-BLOCK(LP1MN))
      GO TO 3301
 3201 DO 3209 N=1,L
      IF((2.0-THPER)*BLOCK(L+1)-BLOCK(LP1MN))3215,3115,3209
 3209 CONTINUE
 3211 GO TO 3009
 3215 YTH=Y(LP2MN)+((2.0-THPER)*BLOCK(L+1)-BLOCK(LP2MN))*(Y(LP2MN)-Y(LP1
     1MN))/(BLOCK(LP2MN)-BLOCK(LP1MN))
 3301 RETURN
      END(1,1,0,0,0,0,0,1,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
800	01440	23198	55236

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	AAU	23204	55244
AB1T	32552	77450	AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	AB5T	32548	77444
AB6T	32547	77443	AB7T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426
ASR	32533	77425	AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222
B4T	32342	77126	B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	BB1T	32102	76546
BB2T	32101	76545	BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541
BB7T	32096	76540	BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430
BU12	32014	76416	C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041
CM1	30143	72677	CM2	30133	72665	CM	30743	74027	CONEAN	29533	71535	CPE	29531	71533
CP	29532	71534	C	32013	76415	CSR	28930	70402	CS	29530	71532	CSUB	23214	55256
DCDP12	28920	70370	DEL	28910	70356	DELTAP	28909	70355	DELTAX	28908	70354	DELXOD	28907	70353
DELXST	28906	70352	DHDP12	28905	70351	DIST	28904	70350	DKDL	28903	70347	DKDT	28303	67217
DN2DD2	27702	66066	DN2	27703	66067	DNO	27701	66065	DO2	27700	66064	DSCRIP	27699	66063
DUDP12	27698	66062	EDENS	27697	66061	EHP	23203	55243	EPSIC	27636	65764	EPSIH	27635	65763
EPSI	27637	65765	EPSIT	27634	65762	EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757
FB	27630	65756	FC	27629	65755	FEDA	27628	65754	FEDB	27627	65753	FEDC	27626	65752
FH12	27565	65655	FHCALC	27564	65654	FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557
FH	27625	65751	FHS	27383	65367	FIND	27323	65273	FKPSI	27321	65271	FK	27322	65272
FLELIN	27260	65174	FLETIN	27259	65173	FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002
FLNOP	27018	64612	FLNO	27078	64706	FLO2	26958	64516	FL	27261	65175	FM	26898	64422
FMUL12	26828	64314	FMUL	26888	64410	FMUTIM	26827	64313	FMUTIP	26767	64217	FNDSSH	26707	64123
FNDSSL	26706	64122	FNUREW	23215	55257	FNUREX	23216	55260	FSH12	23210	55252	FSHE	26645	64025
FSHI12	26044	62674	FSHI	26644	64024	FSHP	26034	62662	FSH	26705	64121	FSK15	23202	55242
FSKRA	26032	62660	FSKRB	26022	62646	FSKRC	26012	62634	FSKRD	26002	62622	FSKRE	26001	62621
FSKRF	26000	62620	FSKRK	25999	62617	FSK	26033	62661	FSME5	23199	55237	FSME	25989	62605
FSMN15	23200	55240	FSMMOP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604	FSMO15	23201	55241
FSMO	25985	62601	GAMM	25984	62600	HE	25983	62577	HH	25982	62576	IALT	25977	62571
IDEL	25976	62570	INDCOD	25975	62567	INDLAS	25965	62555	INDPRI	25954	62542	INDP	25955	62543
INDPS	25953	62541	INDR	25903	62457	INDSTP	25902	62456	INDSTR	25901	62455	INDTYP	25900	62454
IPRINT	23213	55255	JBYCTR	23211	55253	JINPUT	25890	62442	JS	25889	62441	KS	25888	62440
LP2	25886	62436	L	25887	62437	NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433
NS	25884	62434	OGIVEH	25882	62432	OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322
PRAL	25870	62416	PRATIN	25749	62225	PRAT	25809	62321	PRDIRA	25748	62224	PRDS	25688	62130
PRP	25687	62127	PR	25871	62417	PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305
PSI	25225	61211	PSITCU	25165	61115	PS	25685	62125	QW	25164	61114	RESTAR	25162	61112
RETHET	23219	55263	REW	23217	55261	REX	23218	55262	RHO12	25040	60720	RHOCAL	25101	61015
RHOE	25041	60721	RHO	25161	61111	RHOSTO	25039	60717	RHOU12	23205	55245	RN	25038	60716
RNS	25037	60715	R	25163	61113	RSC	24986	60632	RSM	24985	60631	RS	24987	60633
SCHLIN	24984	60630	SCHTIN	24983	60627	SCL	24982	60626	SCT	24922	60532	SHANGL	24862	60436
SIGMAC	24861	60435	SIGMAH	24801	60341	SIGMAU	24741	60245	STADIS	24681	60151	STRLL	23207	55247
S.RUL	23206	55246	T12	23209	55251	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664
THETAT	24499	57663	THPLR	24498	57662	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644
TITLE3	24472	57630	TM	24460	57614	T	24680	60150	TVN2	24400	57520	TVNOP	24398	57516
TVNO	24399	57517	TVO2	24397	57515	U12	24336	57420	UCALC	24335	57417	UE	24275	57323
UINF	24274	57322	ULOLIM	24273	57321	UM1	24212	57224	UM2	24152	57130	UM	24272	57320
U	24396	57514	US	24092	57034	WDOT	24032	56740	XI	23431	55607	XL	23430	55606
XLS	23429	55605	XRN	23379	55523	X	23432	55610	XS	23378	55522	XU12	23377	55521

Y12	23208	55250	YCALC	23316	55424	Y	23376	55520	YTHC	23255	55327	YTH	23256	55330
YTHU	23245	55315	Z1L	23243	55313	Z1R	23242	55312	Z1	23244	55314	Z1S	23232	55300
Z2R	23230	55276	Z2	23231	55277	Z2S	23220	55264						

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
BBU	799	01437	DEL12	798	01436	DELH12	797	01435	FN	796	01434	J	795	01433
LP1MN	794	01432	LP2MN	793	01431	N	792	01430	PFACTR	791	01427	SUMDP	790	01426

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)NE	750	01405	811F6	1510	01402	811RI	1906	01376						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	774	01406	2)	715	01313	3)	721	01321	6)	754	01362	C)G1	781	01415
C)G2	782	01416	C)G3	783	01417	C)G4	784	01420	C)G5	785	01421	C)101	786	01422
C)200	787	01423	C)2G2	788	01424	C)203	789	01425	D)21D	649	01211	D)21L	692	01264
D)40A	257	00401	D)40H	312	00470	D)40J	341	00525	D)41M	710	01306	D)60A	256	00400
D)60J	340	00524	D)61M	709	01305	E)5	162	00242	E)A	259	00403	E)B	266	00412
E)G	296	00450	E)17	610	01142	E)1H	680	01250	E)1J	687	01257	E)119	620	01154
E)318	616	01150												

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP(3	0	00000	LOG	4	00004	SQRT	1	00001	(FIL)	3	00003	(SPH)	5	00005
(STH)	2	00002												

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP(3 LOG SQRT (FIL) (SPH) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
100	15	00033	120	16	00037	140	39	00123	145	68	00231	600	71	00243
700	75	00257	800	81	00334	910	82	00344	920	83	00350	950	84	00404
1000	85	00413	1010	87	00424	1200	88	00431	1250	90	00434	1300	94	00451
1310	97	00471	1400	100	00526	1450	105	00550	1470	111	00567	1650	122	00724
1900	123	00727	1905	125	00771	1910	127	01000	2000	134	01026	2200	135	01036
2300	139	01064	2310	147	01103	2500	154	01121	3000	157	01132	3001	158	01135
3005	159	01143	3009	160	01151	3101	162	01155	3109	166	01203	3111	167	01210
3115	168	01212	3119	170	01215	3201	172	01233	3209	174	01260	3211	175	01263
3215	176	01265	3301	177	01307									

```
      SUBROUTINE HSOLUT
C
      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
     4CSR,DCOP12,DEL,DELTAP,DELTAX,DELXOD,DELXST,DHOP12,DIST,OKOL,
     5OKDT,ON2,ON2002,ONO,OO2,OSCRIP,OUDP12,EDENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEOB,
     7FEOC,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
      COMMON FINO,FK,FKPSI,FL,FLELIN,FLETIN,FLEWL,FLEWT,
     1FLN2,FLNO,FLNOP,FLO2,FM,FMUL,FMUL12,FMUT1M,FMUT1P,FNDSSH,
     2FNOSSL,FSH,FSHE,FSHI,FSHI12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMNO,FSMNOP,FSMO,GAMM,HE,
     4HH,IALT,IOEL,INDCOO,INOLAS,INDP,INOPRI,INDPS,INDR,
     5INOSTP,INOSTR,INOTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     6OGIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PROIRA
      COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITOU,QW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STAOIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVNO,TVNOP,TVO2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
     6UM2,US,WDOT,X,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
     1,FSH12,T12,Y12,STRLL,STRUL,RHOU12,AAU
C
      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),DCOP12(10),DKDL(60,10),DKDT(60,10),
     4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
     5FKPS(60),FLEWL(60),FLEWT(60),FLN2(60),FLNO(60),
     6FLNOP(60),FLO2(60),FM(10),FMUL(60),FMUT1M(60)
      DIMENSION FMUT1P(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INOCOO(10),
     2INOLAS(10),INOPS(50),INDPS(10),P(8),PROIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(50),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)
C
 2500 FHM(1)=HH(1)+XRN*(HH(2)+XRN*(HH(3)+XRN*(HH(4)+HH(5)*XRN)))
 2505 DO 2550 N=2,L
      SUMHL=0.0
      SUMHT=0.0
      SUMHPL=0.0
      SUMHPT=0.0
      IF(N-2) 2508,2508,2520
 2508 UAVG1=RS*(RHO12*U12*U12*DUOP12+RHO(2)*U(2)*U(2)*((U(2)+U(3))*.5-U12
     1)/OELTAP)
      UAVG2=.5*RS/OELTAP*((RHO(3)*U(3)*U(3)+RHO(2)*U(2)*U(2))*(U(3)-U(2)
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     1)+RHO(2)*U(2)*U(2)*(U(2)+U(3)-2.*U12))
      IF(ABSF((FH(1)-FH(2))/FH(1))-.05) 2520,2510,2510
2510 DO 2512 I=1,NS
      SUMHL=SUMHL+2.0*FSHI12(I)*(DKOL(N,I)+DKOL(N-1,I))*DCOP12(I)
2512 SUMHT=SUMHT+2.0*FSHI12(I)*(DKDT(N,I)+OKOT(N-1,I))*OCOP12(I)
      RURN=2.0*RHOU12*RS
      PART 2=.25*RURN*(A4L*FMUL12*(1.0/PRAL(N)+1.0/PRAL(N-1))+A4T*2.0*(F
     IMUT1M(N)/PRAT(N-1)))*DHDP12+(A4L*(FMUL(2)+FMUL12)*(1.-1./PRAL(2))*
     2.5+A4T*FMUT1M(2)*(1.-1./PRAT(2)))*UAVG1
      PARTC2=.125 *(2.0-1.0/FLEWL(N)-1.0/FLEWL(N-1))*(1.0/SCL(N)+1.0/SCL
     1(N-1))*RURN*A5L*FMUL12*.25*SUMHL+.125*(2.0-1.0/FLEWT(N)-1.0/FLEWT(
     2N-1))*(1.0/SCT(N)+1.0/SCT(N-I))*RURN*A5T*FMUT1M(N)*.25*SUMHT
      GO TO 2530
2520 UAVG1=.5*RS/OELTAP*(RHO(N)*U(N)*U(N)*(U(N+1)-U(N-1))+(RHO(N)*U(N)*
     1U(N)+RHO(N-1)*U(N-1)*U(N-1))*(U(N)-U(N-1)))
      UAVG2=.5*RS/DELTAP*(RHO(N)*U(N)*U(N)*(U(N+1)-U(N-1))+(RHO(N+1)*U(N
     1+1)*U(N+1)+RHO(N)*U(N)*U(N))*(U(N+1)-U(N)))
      DO 2525 I=1,NS
      SUMHL=SUMHL+(FSHI(N,I)+FSHI(N-1,I))*(OKDL(N,I)+OKOL(N-1,I))
     1*(C(N,I)-C(N-1,I))/OELTAP
2525 SUMHT=SUMHT+(FSHI(N,I)+FSHI(N-1,I))*(DKDT(N,I)+OKOT(N-1,I))
     I*(C(N,I)-C(N-1,I))/OELTAP
      RURN=RS*(RHO(N)*U(N)+RHO(N-1)*U(N-1))
2526 PARTH2=.25*RURN*(A4L*(FMUL(N)/PRAL(N)+FMUL(N-
     11)/PRAL(N-1))+A4T*2.0*(FMUT1M(N)/PRAT(N-1)))*(FH(N)-FH
     2(N-1))/OELTAP+(A4L*.25*(FMUL(N-1)*(1.-1./PRAL(N-I))+3.*FMUL(N)*(1.
     3-1./PRAL(N)))+A4T*FMUT1M(N)*(1.-1./PRAT(N)))*UAVG1
2528 PARTC2=.0625*(2.0-1.0/FLEWL(N)-1.0/FLEWL(N-I))*(1.0/SCL(N)+1.0/SCL
     1(N-1))*RURN*A5L*(FMUL(N)+FMUL(N-1))*.25*SUMHL
     2+.125*(2.0-1.0/FLEWT(N)-1.0/FLEWT(N-1))*(1.0/SCT(
     3N)+1.0/SCT(N-1))*RURN*A5T*FMUT1M(N)*.25*SUMHT
2530 DO 2534 I=1,NS
      SUMHPL=SUMHPL+(FSHI(N+1,I)+FSHI(N,I))*(OKOL(N+1,I)+OKOL(N,I))
     I*(C(N+1,I)-C(N,I))/DELTAP
2534 SUMHPT=SUMHPT+(FSHI(N+1,I)+FSHI(N,I))*(OKDT(N+1,I)+OKDT(N,I))
     1*(C(N+1,I)-C(N,I))/OELTAP
      RURNP=RS*(RHO(N+1)*U(N+1)+RHO(N)*U(N))
2540 ESCRH=.25*RURNP*(A4L*(FMUL(N+1)/PRAL(N+1)+FMUL(N)/PRAL(N))+A4T*2.*
     1(FMUT1P(N)/PRAT(N)))*(FH(N+1)-FH(N))/DELTAP+(A4L*.25*(FMUL(N+1)*(1
     2.-1./PRAL(N+1))+3.*FMUL(N)*(1.-1./PRAL(N)))+A4T*FMUT1P(N)*(1.-1./P
     3RAT(N)))*UAVG2-PARTH2
      ESCRC=.0625*RURNP*(2.0-1.0/FLEWL(N+1)-1.0/FLEWL(N))*(1.0/SCL(N+1)+
     11.0/SCL(N))*A5L*(FMUL(N+1)+FMUL(N))*.25*SUMHPL
     2                                +.125*(2.0-1.0/FLEWT(N+1)-1.0/FLEWT
     3(N))*(1.0/SCT(N+1)+1.0/SCT(N))*RURNP*A5T*FMUT1P(N)*.25
     4*SUMHPT-PARTC2
2550 FHM(N)=FH(N)+RS*OELTAX/DELTAP*(ESCRH+ESCRC)
      FHM(L+1)=FHE
      FHM(L+2)=FHE
      DO 2600 N=2,L
      IF(FHM(L+1)-FHM(N)) 2570,2600,2600
2570 FHM(N)=FHM(L+1)
2600 CONTINUE
      RETURN
      END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
809	01451	23203	55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	AAU	23204	55244
AB1T	32552	77450	AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	AB5T	32548	77444
AB6T	32547	77443	AB7T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426
ASR	32533	77425	AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222
B4T	32342	77126	B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	BB1T	32102	76546
BB2T	32101	76545	BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541
BB7T	32096	76540	BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430
BU12	32014	76416	C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041
CM1	30143	72677	CM2	30133	72665	CM	30743	74027	CONEAN	29533	71535	CPE	29531	71533
CP	29532	71534	C	32013	76415	CSR	28930	70402	CS	29530	71532	CSUB	23214	55256
OCOP12	28920	70370	OEL	28910	70356	OELTAP	28909	70355	DELTAX	28908	70354	DELXOD	28907	70353
DELXST	28906	70352	OHOP12	28905	70351	OIST	28904	70350	DKDL	28903	70347	DKDT	28303	67217
ON2D02	27702	66066	ON2	27703	66067	ONO	27701	66065	D02	27700	66064	DSCRIP	27699	66063
OUOP12	27698	66062	EDENS	27697	66061	EPSIC	27636	65764	EPSIH	27635	65763	EPSI	27637	65765
EPSIT	27634	65762	EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757	FB	27630	65756
FC	27629	65755	FEOA	27628	65754	FEOB	27627	65753	FEDC	27626	65752	FH12	27565	65655
FHCALC	27564	65654	FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557	FH	27625	65751
FHS	27383	65367	FINO	27323	65273	FKPSI	27321	65271	FK	27322	65272	FLELIN	27260	65174
FLETIN	27259	65173	FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002	FLNOP	27018	64612
FLNO	27078	64706	FLO2	26958	64516	FL	27261	65175	FM	26898	64422	FMUL12	26828	64314
FMUL	26818	64410	FMUTIM	26827	64313	FMUTIP	26767	64217	FNDSSH	26707	64123	FNDSSL	26706	64122
FNUREW	23215	55257	FNUREX	23216	55260	FSH12	23210	55252	FSHE	26645	64025	FSHI12	26044	62674
FSHI	26644	64024	FSHP	26034	62662	FSH	26705	64121	FSKRA	26032	62660	FSKR8	26022	62646
FSKRC	26012	62634	FSKRO	26002	62622	FSKRE	26001	62621	FSKRF	26000	62620	FSKRK	25999	62617
FSK	26033	62661	FSME	25989	62605	FSMNOP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604
FSMO	25985	62601	GAMM	25984	62600	HE	25983	62577	HH	25982	62576	IALT	25977	62571
IOEL	25976	62570	INOC00	25975	62567	INOLAS	25965	62555	INOPRI	25954	62542	INDP	25955	62543
INOPS	25953	62541	INOR	25903	62457	INOSTP	25902	62456	INDSTR	25901	62455	INDTYP	25900	62454
IPRINT	23213	55255	JBYCTR	23211	55253	JINPUT	25890	62442	JS	25889	62441	KS	25888	62440
LP2	25886	62436	L	25887	62437	NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433
NS	25884	62434	OGIVEH	25882	62432	OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322
PRAL	25870	62416	PRATIN	25749	62225	PRAT	25809	62321	PRDIRA	25748	62224	PROS	25683	62130
PRP	25687	62127	PR	25871	62417	PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305
PSI	25225	61211	PSITCU	25165	61115	PS	25685	62125	QW	25164	61114	RESTAR	25162	61112
RETHET	23219	55263	REW	23217	55261	REX	23218	55262	RHO12	25040	60720	RHOCAL	25101	61015
RHOE	25041	60721	RHO	25161	61111	RHOSTG	25039	60717	RHOU12	23205	55245	RN	25038	60716
RNS	25037	60715	R	25163	61113	RSC	24986	60632	RSM	24985	60631	RS	24987	60633
SCHLIN	24984	60630	SCHTIN	24983	60627	SCL	24982	60626	SCT	24922	60532	SHANGL	24862	60436
SIGMAC	24861	60435	SIGMAH	24801	60341	SIGMAU	24741	60245	STADIS	24681	60151	STRLL	23207	55247
STRUL	23206	55246	T12	23209	55251	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664
THETAT	24499	57663	THPER	24498	57662	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644
TITLE3	24472	57630	TM	24460	57614	T	24680	60150	TVN2	24400	57520	TVNOP	24398	57516
TVNO	24399	57517	TVO2	24397	57515	U12	24336	57420	UCALC	24335	57417	UE	24275	57323
UINF	24274	57322	ULOLIM	24273	57321	UM1	24212	57224	UM2	24152	57130	UM	24272	57320
U	24396	57514	US	24092	57034	WDOT	24032	56740	XI	23431	55607	XL	23430	55606
XLS	23429	55605	XRN	23379	55523	X	23432	55610	XS	23378	55522	XU12	23377	55521
Y12	23208	55250	YCALC	23316	55424	Y	23376	55520	YTHC	23255	55327	YTH	23256	55330

YTHU	23245	55315	Z1L	23243	55313	Z1R	23242	55312	Z1	23244	55314	Z1S	23232	55300
Z2R	23230	55276	Z2	23231	55277	Z2S	23220	55264						

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ESCRC	808	01450	ESCRH	807	01447	N	806	01446	PARTC2	805	01445	PARTH2	804	01444
RURNP	803	01443	RURN	802	01442	SUMHL	801	01441	SUMHPL	800	01440	SUMHPT	799	01437
SUMHT	798	01436	UAVG1	797	01435	UAVG2	796	01434						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	774	01406	2)	756	01364	3)	759	01367	6)	768	01400	C)G3	792	01430
C)100	793	01431	C)200	794	01432	C)201	795	01433	D)20A	537	01031	D)409	536	01030
E)2	70	00106												

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
2500	10	00013	2505	11	00033	2508	17	00107	2510	20	00211	2512	22	00227
2520	27	00450	2525	31	00563	2526	33	00617	2528	34	00721	2530	35	01031
2534	37	01051	2540	39	01105	2550	41	01317	2570	46	01354	2600	47	01356

```
      SUBROUTINE PRTERH (X,NSTART,NEND,KS)

      SUBROUTINE PRTERH (X,NSTART,NEND,KS)
C
      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,AL  4A,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,Bb5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
     4CSR,DCDP12,DEL,DELTAP,DELTAX,DELXOD,DELXST,DHDP12,DIST,DKDL,
     5DKDT,DN2,DN2DD2,DND,DD2,DSCRIP,DUDP12,EDENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
     7FEDC,FH,FH12,FHCALC,FHE,FHM,FH42,FHS
      COMMON F(ND),FK,FKPSI,FL,FLELIN,FLETIN,FLEWL,FLEWT,
     1FLN2,FLN1,FLNOP,FLO2,FM,FMUL,FMUL12,FMUT1M,FMUT1P,FNDSSH,
     2FNDSSL,FSH,FSHE,FSHI,FSHI12,FSHP,FSK,FSKRA,FSKRB,FSKPC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMNO,FSMNOP,FSMO,GAMM,HE,
     4HH,IALT,IDEL,INDCOD,INDLAS,INDP,INDPRI,INDPS,INDR,
     5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     6OGIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
      COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,OW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVND,TVNDP,TVO2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
     6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,RNUREX,RNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
     1,FSH12,TI2,YI2
C
      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
     4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
     5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLN1(60),
     6FLNOP(60),FLO2(60),FM(10),FMUL(60),FMUT1M(60)
      DIMENSION FMUT1P(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCOD(10),
     2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)
      DIMENSION HBAR(60),TNUM(60)
C
  100 X=X
      NSTART=NSTART
      NEND=NEND
      KS=KS
      XRN=X/RNS(KS)
  700 IF(NEND-NSTART)800,750,800
  750 IF(INDSTR) 760,760,950
```

```
760 XRM=(X-DELXOD)/RNS(KS)
    GO TO 900
```

```
  800 XRM=(X-DELTAX)/RNS(KS)
  900 IF(INDPS(KS)-2)910,920,930
  910 PR=PS(1,KS)*(COSF(XRM))**2
      PRP=-PS(1,KS)/RNS(KS)*SINF(2.0*XRM)
      PRSAVE=PR
      GO TO 1000
  920 PR=PS(2,KS)+PS(3,KS)*XRM+PS(4,KS)*XRM**2+PS(5,KS)*XRM**3+PS(6,KS)*
     1XRM**4
      PRP=RNS(KS)*(PS(3,KS)+2.0*PS(4,KS)*XRM+3.0*PS(5,KS)*XRM**2+4.0*PSI
     I(6,KS)*XRM**3)
      PRSAVE=PR
      GO TO 1000
  930 PR=PS(7,KS)/(PS(8,KS)+XRM)
      PRP=-PS(7,KS)*RNS(KS)/(X+PS(8,KS)*RNS(KS))**2
      PRSAVE=PR
      GO TO 1000
  950 PR=PRDS+X/DIST*(PRSAVE-PRDS)
      PRP=(PRSAVE-PRDS)/DIST
 1000 IF(NEND-NSTART) 1005,1090,1005
 1005 NEND=NEND+1
      DELT12=.5*DELTAP
      SDEL12=SQRTF(DELT12)
      SDELTP=.58579*SQRTF(DELTAP)
      DELTP=.58579*DELTAP
      AH12=(2.0*FH(2)-FH(1)-FH(3))/SDELTP
      BH12=(FH(3)+.414*FH(1)-1.414*FH(2))/DELTP
      FH(NEND)=FH(1)+AH12*SDEL12+BH12*DELT12
      FH12=FH(NEND)
      DHDP12=.5*AH12/SDEL12+BH12
      AU12=(2.0*U(2)-U(3))/SDELTP
      BU12=(U(3)-1.41421*U(2))/DELTP
      U(NEND)=AU12*SDEL12+BU12*DELT12
      U12=U(NEND)
      DUDP12=.5*AU12/SDEL12+BU12
      DO 1030 I=1,NS
      AC12(I)=(2.0*C(2,I)-C(1,I)-C(3,I))/SDELTP
      BC12(I)=(C(3,I)+.414*C(1,I)-1.414*C(2,I))/DELTP
      IF(C(3,I)+C(2,I)) 1010,1015,1010
 1010 IF(C(2,I)+C(1,I)) 1020,1015,1020
 1015 C(NEND,I)=0
      GO TO 1025
 1020 C(NEND,I)=C(1,I)+AC12(I)*SDEL12+BC12(I)*DELT12
      IF(C(NEND,I)) 1022,1025,1025
 1022 C(NEND,I)=.5*(C(1,I)+C(2,I))
      DCDP12(I)=(C(2,I)-C(1,I))/DELTAP
      GO TO 1030
 1025 DCDP12(I)=.5*AC12(I)/SDEL12+BC12(I)
 1030 C12(I)=C(NEND,I)
 1090 DO 1100 N=NSTART,NEND
 1100 FSH(N)=FH(N)-.5*U(N)**2
      IF(A2) 1150,1110,1115
 1115 IF(A2-9.8) 1110,1110,1150
 1150 PLOG=.43429448*LOGF(PR/2117.)
      C8=230.6335/(110.-PLOG)+.183042*(PLOG+3.)
```

```
C9=2.1965+.31961*(PLOG+4.1)**2
E4=(C9-C8)/(C8+C8-C9-79.4)
```

```
      E2=79.4+(1.+E4)*(C8-79.4)
      E1=(79.4-E2)*E4
      E3=-E1*E4
      C5=-2.1965+1.46434/(EXPF(-2.*PLOG)+1.)
      C6=-.00065+.012096/(PLOG+9.6)
      C7=-94.2-1.6*PLOG*(1.-.5*PLOG)
      CK8=5224./(33.842-PLOG)-1.7609*(PLOG+68.5)
      CK9=12.813+.46218*(PLOG+4.1)**2
      CK4=(CK9-CK8)/(CK8+CK8-CK9-79.4)
      CK2=79.4+(1.+CK4)*(CK8-79.4)
      CK1=(79.4-CK2)*CK4
      CK3=-CK1*CK4
      CK5=-1.83+1.098/(EXPF(-2.*(PLOG-.75))+1.)
      CK6=.00038+.000953/(PLOG+4.5)
      CK7=-84.6-.8*PLOG*(1.-.5*PLOG)
      IF(A2-9.8) 1155,1155,1110
1155  DO 1160 I=NSTART,NEND
      HBAR(I)=FSH(I)/25037.807
      D1=HBAR(I)/8465.
      D2=EXPF(HBAR(I)/1693.-10.)
      D3=HBAR(I)/33.86
      F1=F1+F2*D1+F3/(E4+D1)+C5*EXPF(-C6*(D3+C7)**2)+(5.4913-.56743*(PLO
     1G+1.75)**2)*D2
      F2=CK1+CK2*D1+CK3/(CK4+D1)+CK5*EXPF(-CK6*(D3+CK7)**2)+(9.2217-.276
     139*(PLOG+3.5)**2)*D2
      T(I)=273.16*F1
      TM(I)=T(1)
1160  RHO(I)=PR*1.1799716E-6/F2
      GO TO 1200
1110  DO 1120 N=NSTART,NEND
      TNUM(N)=FSH(N)-1726.0E-18*(.5*C(N,2)*D02/FSMO+.5*C(N,4)*DN2/FSMN+C
     1(N,5)*DN2D02/FSMNO+C(N,6)*(FLNO+DN2D02)/FSMNOP)
1120  T(N)=TNUM(N)/CP
1200  DO 1250 N=NSTART,NEND
      FLO2(N)=TVO2/T(N)/(EXPF(TVO2/T(N))-1.0)
      FLN2(N)=TVN2/T(N)/(EXPF(TVN2/T(N))-1.0)
      FLNO(N)=TVNO/T(N)/(EXPF(TVNO/T(N))-1.0)
1250  FLNOP(N)=TVNOP/T(N)/(EXPF(TVNOP/T(N))-1.0)
      IF(A2) 1500,1300,1300
1300  DO 1350 N=NSTART,NEND
1350  TM(N)=TNUM(N)/(R*(C(N,1)/FM(1)*(FLO2(N)+3.5)+C(N,3)/FM(3)*(FLN2(N)
     1+3.5)+C(N,5)/FM(5)*(FLNO(N)+3.5)+C(N,6)/FM(6)*(FLNOP(N)+3.5)+2.5*(
     2C(N,2)/FM(2)+C(N,4)/FM(4)+C(N,7)/FM(7))))
1400  DO 1450 N=NSTART,NEND
      IF(ABSF((TM(N)-T(N))/TM(N))-EPSIT)1450,1450,1470
1450  CONTINUE
      GO TO 1500
1470  DO 1480 N=NSTART,NEND
1480  T(N)=TM(N)
      GO TO 1200
1500  DO 1520 N=NSTART,NEND
      SUMCM=0.0
      T(N)=TM(N)
      DO 1510 I=1,NS
```

```
1510  SUMCM=SUMCM+C(N,1)/FM(I)
      RTM=R*TM(N)
```

```
      IF(A2) 1519,1517,1517
 1517 RHO(N)=PR/(RTM*SUMCM)
 1519 FSH1(N,1)=RTM*(3.5+FLO2(N))/FM(1)
      FSH1(N,2)=RTM*2.5/FM(2)+DO2*.5/FM(2)
      FSH1(N,3)=RTM*(3.5+FLN2(N))/FM(3)
      FSH1(N,4)=RTM*2.5/FM(4)+DN2*.5/FM(4)
      FSH1(N,5)=(RTM*(3.5+FLNO(N))+DN2DO2)/FM(5)
      FSH1(N,6)=(RTM*(3.5+FLNOP(N))+FINO+DN2DO2)/FM(6)
 1520 FSH1(N,7)=RTM*2.5/FM(7)
      FSH12=FSH(NEND)
      RHO12=RHO(NEND)
      T12=TM(NEND)
      FMUL12=3.04566E-8*TM(NEND)**1.5/(110.333+TM(NEND))
      DO 1600 I=1,NS
 1600 FSH12(I)=FSH1(NEND,I)
      NEND =NEND-1
      IF(A2-9.9) 2000,2000,1700
 1700 HBAR(1)=FSH(1)/25037.807
      D1=HBAR(1)/8465.
      D2=EXPF(HBAR(1)/1693.-10.)
      D3=HBAR(1)/33.86
      F1=E1+E2*D1+E3/(E4+D1)+C5*EXPF(-C6*(D3+C7)**2)+(5.4913-.56743*(PLO
     1G+1.75)**2)*D2
      F2=CK1+CK2*D1+CK3/(CK4+D1)+CK5*EXPF(-CK6*(D3+CK7)**2)+(9.2217-.276
     139*(PLOG+3.5)**2)*D2
      T(1)=273.16*F1
      TM(1)=T(1)
      RHO(1)=PR*1.1799716E-6/F2
      FLO2(1)=TVO2/T(1)/(EXPF(TVO2/T(1))-1.0)
      FLN2(1)=TVN2/T(1)/(EXPF(TVN2/T(1))-1.0)
      FLNO(1)=TVNO/T(1)/(EXPF(TVNO/T(1))-1.0)
      FLNOP(1)=TVNOP/T(1)/(EXPF(TVNOP/T(1))-1.0)
      RTM=R*TM(1)
      FSH1(1,1)=RTM*(3.5+FLO2(1))/FM(1)
      FSH1(1,2)=RTM*2.5/FM(2)+DO2*.5/FM(2)
      FSH1(1,3)=RTM*(3.5+FLN2(1))/FM(3)
      FSH(1,4)=RTM*2.5/FM(4)+DN2*.5/FM(4)
      FSH1(1,5)=(RTM*(3.5+FLNO(1))+DN2DO2)/FM(5)
      FSH1(1,6)=(RTM*(3.5+FLNOP(1))+FINO+DN2DO2)/FM(6)
      FSH1(1,7)=RTM*2.5/FM(7)
 2000 RETURN
      END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
1463	02667	23207	55247

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	AB1T	32552	77450
AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	AB5T	32548	77444	AB6T	32547	77443
AB7T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426	ASR	32533	77425
AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222	B4T	32342	77126
B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	BB1T	32102	76546	BB2T	32101	76545
BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541	BB7T	32096	76540
BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430	BU12	32014	76416
C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041	CM1	30143	72677
CM2	30133	72665	CM	30743	74027	CONEAN	29533	71535	CPE	29531	71533	CP	29532	71534
C	32013	76415	CSR	28930	70402	CS	29530	71532	CSUB	23214	55256	DCDP12	28920	70370
DEL	28910	70356	DELTAP	28909	70355	DELTAX	28908	70354	DELXOD	28907	70353	DELXST	28906	70352
DHDP12	28905	70351	DIST	28904	70350	DKDL	28903	70347	DKOT	28303	67217	DN2DP2	27702	66066
DN2	27703	66067	DNO	27701	66065	DO2	27700	66064	DSCRIP	27699	66063	DUDP12	27698	66062
EDENS	27697	66061	EPSIC	27636	65764	EPSIH	27635	65763	EPSI	27637	65765	EPSIT	27634	65762
EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757	FB	27630	65756	FC	27629	65755
FEDA	27628	65754	FEDB	27627	65753	FEDC	27626	65752	FH12	27565	65655	FHCALC	27564	65654
FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557	FH	27625	65751	FHS	27383	65367
FINO	27323	65273	FKPSI	27321	65271	FK	27322	65272	FLFLIN	27260	65174	FLFTIN	27259	65173
FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002	FLNOP	27018	64612	FLNO	27078	64706
FL02	26958	64516	FL	27761	65175	FM	26898	64422	FMUL12	26828	64314	FMUL	26888	64410
FMUTIM	26827	64313	FMUT1P	26767	64217	FNDSSH	26707	64123	FNDSSL	26706	64122	FNUREW	23215	55257
FNUREX	23216	55260	FSH12	23210	55252	FSHF	26645	64025	FSHI12	26044	62674	FSHI	26644	64024
FSHP	26034	62662	FSH	26705	64121	FSKRA	26032	62660	FSKRB	26022	62646	FSKRC	26012	62634
FSKRD	26002	62622	FSKRE	26001	62621	FSKRF	26000	62620	FSKRK	25999	62617	FSK	26033	62641
FSME	25989	62605	FSMNDP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604	FSMO	25985	62601
GAMM	25984	62600	HE	25983	62577	HH	25982	62576	IALT	25977	62571	IDEL	25976	62570
INDC30	25975	62567	INDLAS	25965	62555	INDPR1	25954	62542	INDP	25955	62543	INDPS	25953	62541
INDR	25903	62457	INDSTP	25902	62456	INDSTR	25901	62455	INDTYP	25900	62454	IPRINT	23213	55255
JBYCTR	23211	55253	JINPUT	25890	62442	JS	25889	62441	LP2	25886	62436	L	25887	62437
NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433	NS	25884	62434	OGIVEH	25882	62432
OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322	PRAL	25870	62416	PRATIN	25749	62225
PRAT	25809	62321	PRDIRA	25748	62224	PRDS	25688	62130	PRP	25687	62127	PR	25871	62417
PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305	PSI	25225	61211	PSITCU	25165	61115
PS	25685	62125	QW	25164	61114	RESTAR	25162	61112	RETHET	23219	55263	REW	23217	55261
REX	23218	55262	RHO12	25040	60720	RHOCAL	25101	61015	RHOE	25041	60721	RHO	25161	61111
RHOSTG	25039	60717	RN	25038	60716	RNS	25037	60715	R	25163	61113	RSC	24986	60632
RSM	24985	60631	RS	24987	60633	SCHLIN	24984	60630	SCHTIN	24983	60627	SCL	24982	60626
SCT	24922	60532	SHANGL	24862	60436	SIGMAC	24861	60435	SIGMAH	24801	60341	SIGMAU	24741	60245
STADIS	24681	60151	T12	23209	55251	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664
THETAT	24499	57663	THPER	24498	57662	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644
TITLE3	24472	57630	TM	24460	57614	T	24680	60150	TVN2	24400	57520	TVNDP	24398	57516
TVNO	24399	57517	TVO2	24397	57515	U12	24336	57420	UCALC	24335	57417	UF	24275	57323
UINF	24274	57322	ULOLIM	24273	57321	UM1	24212	57224	UM2	24152	57130	UM	24272	57320
U	24396	57514	US	24092	57034	WDOT	24032	56740	XI	23431	55607	XL	23430	55606

XLS 23429 55605	XRN 23379 55523	XS 23378 55522	XU12 23377 555..	Y12 23208 55250
YCALC 23316 55424	Y 23376 55520	YTHC 23255 55327	YTH 23256 55330	YTHU 23245 55315
Z1L 23243 55313	Z1R 23242 55312	Z1 23244 55314	Z1S 23232 55300	Z2R 23230 55276
Z2 23231 55277	Z2S 23220 55264			

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
HBAR	1462	02666	TNUM	1402	02572									

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
C5	1342	02476	C6	1341	02475	C7	1340	02474	C8	1339	02473	C9	1338	02472
CK1	1337	02471	CK2	1336	02470	CK3	1335	02467	CK4	1334	02466	CK5	1333	02465
CK6	1332	02464	CK7	1331	02463	CK8	1330	02462	CK9	1329	02461	D1	1328	02460
D2	1327	02457	D3	1326	02456	DELT12	1325	02455	DELTP	1324	02454	E1	1323	02453
E2	1322	02452	E3	1321	02451	E4	1320	02450	F1	1319	02447	F2	1318	02446
N	1317	02445	PLOG	1316	02444	RTM	1315	02443	SDEL12	1314	02442	SDELTP	1313	02441
SUMCM	1312	02440	XRM	1311	02437									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	1293	02415	2)	1223	02307	3)	1230	02316	6)	1287	02407	A)100	1214	02276
C)G0	1304	02430	C)G2	1305	02431	C)G3	1306	02432	C)100	1307	02433	C)101	1308	02434
C)102	1309	02435	C)103	1310	02436	D)408	321	00501	D)508	320	00500	E)D	345	00531
E)F	365	00555	F)1K	1005	01755									

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
COS	0	00000	EXP	4	00004	EXP(3	5	00005	LOG	3	00003	SIN	1	00001
SQRT	2	00002												

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

COS EXP EXP(3 LOG SIN SQRT

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
100	11	00113	700	16	00136	750	17	00143	760	18	00146	800	20	00153
900	21	00157	910	22	00163	920	26	00212	930	30	00307	950	34	00334
1000	36	00346	1005	37	00351	1010	56	00524	1015	57	00534	1020	59	00542
1022	61	00560	1025	64	00573	1030	65	00600	1090	66	00606	1100	67	00611
1115	69	00627	1150	70	00634	1155	90	01122	1160	99	01271	1110	101	01300
1120	103	01337	1200	104	01345	1250	108	01414	1300	110	01436	1350	111	01442
1400	112	01522	1450	114	01541	1470	116	01544	1480	117	01547	1500	119	01554
1510	123	01575	1517	126	01616	1519	127	01624	1520	133	01702	1600	139	01737
1700	142	01756	2000	163	02272									

```
      SUBROUTINE RADBDY
C
      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
     4CSR,OCOP12,DEL,DELTAP,DELTAX,DELXDO,DELXST,DHOP12,DIST,DKDL,
     5DKDT,DN2,DN2DD2,DNO,DD2,OSCRIP,DUOP12,EOENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEOA,FEOB,
     7FEDC,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
      COMMON FINO,FK,FKPSI,FL,FLELIN,FLETIN,FLEWL,FLEWT,
     1FLN2,FLNO,FLNDP,FLO2,FM,FMUL,FMUL12,FMUT1M,FMUT1P,FNOSSH,
     2FNOSSL,FSH,FSHE,FSHI,FSHI12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMND,FSMNDP,FSMO,GAMH,HE,
     4HH,IALT,IDEL,INDCOO,INOLAS,INDP,INOPR),INOPS,INOR,
     5INOSTP,INOSTR,INOTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     6OGIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
      COMMON PROS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STAOIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVNO,TVNOP,TVO2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
     6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
C
      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),OCOP12(10),DKDL(60,10),DKDT(60,10),
     4EOENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
     5FKPS)(60),FLEWL(60),FLEWT(60),FLN2(60),FLNO(60),
     6FLNOP(60),FLO2(60),FM(10),FMUL(60),FMUT1M(60)
      DIMENSION FMUT1P(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCOO(10),
     2INDLAS(10),INDPS(50),INOTYP(10),P(8),PRDIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)
C
      GO TO (100,200,300,400,500),INDR
  100 IF(KS-2) 110,120,120
  110 Z2=RN*SINF(XRN+ALPHA-XS/RN)+OGIVEK
      Z1=OGIVEH-RN*COSF(XRN+ALPHA-XS/RN)
      GO TO 130
  120 Z2=RN*SINF(XRN+ALPHA-XLS(KS-1)/RN)+OGIVEK
      Z1=OGIVEH-RN*COSF(XRN+ALPHA-XLS(KS-1)/RN)
  130 RSM=Z2
      GO TO 330
  200 IF(KS-2)210,220,220
  210 Z2=(X-XS)*SINF(CONEAN)+Z2S
```

```
     Z1=(X-XS)*COSF(CONEAN)+Z1S
     GO TO 230
220  Z2=(X-XLS(KS-1))*SINF(CONEAN)+Z2S
     Z1=(X-XLS(KS-1))*COSF(CONEAN)+Z1S
230  RSM=Z2
     GO TO 330
300  Z2=Z2S
     RSM=Z2
     IF(KS-2)310,320,320
310  Z1=Z1S+(X-XS)
     GO TO 330
320  Z1=X-XLS(KS-1)+Z1S
330  IF(EPSI) 550,700,800
400  GO TO 100
500  GO TO 300
550  STOP 550
700  RSM=1.0
800  RETURN
     END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
193	00301	23210	55252

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	AB1T	32552	77450
AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	AB5T	32548	77444	AB6T	32547	77443
AB7T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426	ASR	32533	77425
AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222	B4T	32342	77126
B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	BB1T	32102	76546	BB2T	32101	76545
BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541	BB7T	32096	76540
BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430	BU12	32014	76416
C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041	CM1	30143	72677
CM2	30133	72665	CM	30743	74027	CONEAN	29533	71535	CPE	29531	71533	CP	29532	71534
C	32013	76415	CSR	28930	70402	CS	29530	71532	CSUB	23214	55256	DCDP12	28920	70370
DEL	28910	70356	DELTAP	28909	70355	DELTAX	28908	70354	DELX00	28907	70353	DELXST	28906	70352
DHDP12	28905	70351	DIST	28904	70350	DKDL	28903	70347	DKDT	28303	67217	DN2002	27702	66066
DN2	27703	66067	DNO	27701	66065	DU2	27700	66064	DSCRIP	27699	66063	DUDP12	27698	66062
EDENS	27697	66061	EPSIC	27636	65764	EPSIH	27635	65763	EPSI	27637	65765	EPSIT	27634	65762
EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757	FB	27630	65756	FC	27629	65755
FEDA	27628	65754	FEDB	27627	65753	FEDC	27626	65752	FH12	27565	65655	FHCALC	27564	65654
FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557	FH	27625	65751	FHS	27383	65367
FINO	27323	65273	FKPSI	27321	65271	FK	27322	65272	FLELIN	27260	65174	FLETIN	27259	65173
FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002	FLNOP	27018	64612	FLNO	27078	64706
FLO2	26958	64516	FL	27261	65175	FM	26898	64422	FMUL12	26828	64314	FMUL	26868	64410
FMUT1M	26827	64313	FMUT1P	26767	64217	FNDSSH	26707	64123	FNDSSL	26706	64122	FNUREW	23215	55257
FNUREX	23216	55260	FSHE	26645	64025	FSHI12	26044	62674	FSHI	26644	64024	FSHP	26034	62662
FSH	26705	64121	FSKRA	26032	62660	FSKRB	26022	62646	FSKRC	26012	62634	FSKRD	26002	62622
FSKRE	26001	62621	FSKRF	26000	62620	FSKRK	25999	62617	FSK	26033	62661	FSME	25989	62605
FSMNOP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604	FSMO	25985	62601	GAMM	25984	62600
HE	25983	62577	HH	25982	62576	IALT	25977	62571	IDEL	25976	62570	INDC00	25975	62567
INDLAS	25965	62555	INDPRI	25954	62542	INDP	25955	62543	INDPS	25953	62541	INDR	25903	62457
INDSTP	25902	62456	INDSTR	25901	62455	INDTYP	25900	62454	IPRINT	23213	55255	JBYCTR	23211	55253
JINPUT	25890	62442	JS	25889	62441	KS	25888	62440	LP2	25886	62436	L	25887	62437
NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433	NS	25884	62434	OGIVEH	25882	62432
OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322	PRAL	25870	62416	PRATIN	25749	62225
PRAT	25809	62321	PRDIRA	25748	62224	PRDS	25688	62130	PRP	25687	62127	PR	25871	62417
PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305	PSI	25225	61211	PSITCU	25165	61115
PS	25685	62125	QW	25164	61114	RESTAR	25162	61112	RETHET	23219	55263	REW	23217	55261
REX	23218	55262	RHO12	25040	60720	RHOCAL	25101	61015	RHOE	25041	60721	RHO	25161	61111
RHOSTG	25039	60717	RN	25038	60716	RNS	25037	60715	R	25163	61113	RSC	24986	60632
RSM	24985	60631	RS	24987	60633	SCHLIN	24984	60630	SCHTIN	24983	60627	SCL	24982	60626
SCT	24922	60532	SHANGL	24862	60436	SIGMAC	24861	60435	SIGMAH	24801	60341	SIGMAU	24741	60245
STADIS	24681	60151	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664	THETAT	24499	57663
THPER	24498	57662	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644	TITLE3	24472	57630
TM	24460	57614	T	24680	60150	TVN2	24400	57520	TVNOP	24398	57516	TVNO	24399	57517
TVO2	24397	57515	U12	24336	57420	UCALC	24335	57417	UE	24275	57323	UINF	24274	57322
ULOLIM	24273	57321	UM1	24212	57224	UM2	24152	57130	UM	24272	57320	U	24396	57514
US	24092	57034	WDOT	24032	56740	XI	23431	55607	XL	23430	55606	XLS	23429	55605
XRN	23379	55523	X	23432	55610	XS	23378	55522	XU12	23377	55521	YCALC	23316	55424
Y	23376	55520	YTHC	23255	55327	YTH	23256	55330	YTHU	23245	55315	Z1L	23243	55313
Z1R	23242	55312	Z1	23244	55314	Z1S	23232	55300	Z2R	23230	55276	Z2	23231	55277
Z2S	23220	55264												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	188	00274	2)	180	00264	3)	181	00265	6)	182	00266	C)GO	191	00277
C)G1	192	00300	E)1	18	00022	E)2	24	00030	E)5	88	00130	E)E	166	00246
E)H	174	00256	E)109	142	00216									

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
COS	1	00001	SIN	0	00000									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

COS SIN

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
100	11	00024	110	12	00032	120	15	00070	130	17	00125	200	19	00132
210	20	00136	220	23	00165	230	25	00213	300	27	00220	310	30	00230
320	32	00235	330	33	00241	400	34	00245	500	35	00250	550	36	00251
700	37	00253	800	38	00260									

```
      SUBROUTINE STAOUT(KK)
      SUBROUTINE STAOUT(KK)
C
      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
     4CSR,DCDP12,DEL,DELTAP,DELTAX,DELXOD,DELXST,DHDP12,DIST,DKDL,
     5DKDT,DN2,DN2D02,DNO,D02,DSCRIP,DUDP12,EDENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
     7FEDC,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
      COMMON FINO,FK,FKPSI,FL,FLELIN,FLETIN,FLEWL,FLEWT,
     1FLN2,FLNO,FLNOP,FLO2,FM,FMUL,FMUL12,FMUT1M,FMUT1P,FNDSSH,
     2FNDSSL,FSH,FSHE,FSHI,FSH112,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMNO,FSMNOP,FSMO,GAMM,HE,
     4HH,IALT,IDEL,INDCOO,INDLAS,INDP,INDPRI,INDPS,INDR,
     5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     60GIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
      COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVNO,TVNOP,TV02,U,U12,UCALC,UE,UINF,ULOL1M,UM,UM1,
     6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
     1,FSH12,T12,Y12,STRLL,STRUL,RHOU12,AAU
C
      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10)
     4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
     5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLNO(60),
     6FLNOP(60),FLO2(60),FM(10),FMUL(60),FMUT1M(60)
      DIMENSION FMUT1P(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCOO(10),
     2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)
C
      KK=KK
      IF(KK-2) 5800,6041,6046
 5000 FORMAT(//1H044HFLIGHT CONDITIONS AND FREE STREAM PROPERTIES//)
 5005 FORMAT(6X3HALT13X2HCP9X9HSTAT ENTH8X5HGAMMA10X5HPRESS9X7HDENSITY9X
     14HTEMP12X3HVEL/5X6H(K FT)5X13H(FT/SEC) SQ/K3X11H(FT/SEC) SQ19X10H(
     2LB/SQ FT)4X13H(SLUGS/CU FT)5X7H(DEG K)8X8H(FT/SEC)/I9,1PE19.5,1P6E
     315.5)
 5010 FORMAT(/5X5HC(02)11X4HC(O)10X5HC(N2)10X4HC(N)11X5HC(NO)9X6HC(NO+)1
     10X5HC(E-)/1PE13.5,1P6E15.5)
 5015 FORMAT(///17H SHOCK CONDITIONS//)
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5020 FORMAT(15H  STAG DENSITY 6X3HNSR/14H (SLUGS/CU FT)/1PE13.5,I10)
5025 FORMAT(//18H SHOCK REGION NO  I2//6X4HTYPE10X6HSHANGL5X13HSTANDOFF
    1 DIST19X9HGEOM COEF30X6HLIMITS/20X5H(RAD)10X4H(FT)12X3HASR12X3HBSR
    212X3HCSR9X8HZ1R (FT)7X8HZ2R (FT))
5030 FORMAT(4X8HSTRAIGHT3X1PE13.5,1P6E15.5)
5035 FORMAT(4X7HCONICAL4X1PE13.5,1P6E15.5)
5038 FORMAT(5X6HNORMAL4X1PE13.5,1P6E15.5)
5040 FORMAT(3X12HPARABOLIC   1PE13.5,1P6E15.5)
5045 FORMAT(///34H PROBLEM PARAMETERS AND INDICATORS//13H PROBLEM TYPE/
    1)
5050 FORMAT(5X15HINITIAL PROFILE15X24HCONSTANT EDGE CONDITIONS15X22HINI
    1TIAL PROFILES INPUT)
5055 FORMAT(5X15HINITIAL PROFILE15X15HSTREAMLINE CALC15X22HINITIAL PROF
    1ILES INPUT)
5060 FORMAT(5X14HSHOCK CROSSING16X15HSTREAMLINE CALC15X22HINITIAL PROFI
    1LES INPUT)
5065 FORMAT(/15H  NO GRID PTS  15H  NO SPECIES   15H  NOSE RADIUS  15H
    1 OVERALL ZETA 6X4HNPSI10X6HJINPUT9X6HRESTAR/35X4H(FT)12X4H(FT)/I8,
    2I16,1PE19.5,1PE15.5,I11,I14,1PE20.5)
5070 FORMAT(/6X2HXS13X3HZ1S12X3HZ2S11X6HDELTAX/5X4H(FT)12X4H(FT)11X4H(F
    1T)11X4H(FT)/1PE13.5,1P3E15.5)
5075 FORMAT(/6X3HA1L12X3HA1T12X2HA213X3HA3L12X3HA3T12X3HA4L12X3HA4T/1PE
    113.5,1P6E15.5//6X3HA5L12X3HA5T11X20HSTEP SIZE TOLERANCES7X12HSTAB.
    2 FACTOR/1PE13.5,1P4E15.5)
5080 FORMAT(/4X7HU LOLIM44X18HTHICKNESS CRITERIA/4X8H(FT/SEC)10X7HU12X5
    1HC(O2)11X4HC(O)10X5HC(N2)11X4HC(N)10X5HC(NO)12X1HH/1PE13.5,1P7E15.
    25)
5085 FORMAT(/4X4HEPSI5X6HEPSI U6X10HEPSI C(O2)2X9HEPSI C(O)3X10HEPSI C(
    1N2)2X9HEPSI C(N)3X10HEPSI C(NO)4X6HEPSI H7X6HEPSI T/1P8E12.5,1PE13
    2.5)
5090 FORMAT(/11X8HLEWIS NO21X10HPRANDTL NO20X10HSCHMIDT NO/4X,7HLAMINAR
    17X9HTURBULENT7X7HLAMINAR7X9HTURBULENT7X7HLAMINAR7X9HTURBULENT/1PE1
    23.5,1P5E15.5)
5095 FORMAT(/30H DIFFUSION COEF RATIOS LAMINAR/)
5100 FORMAT(6X2HO214X1HO13X2HN214X1HN13X2HNO13X3HNO+12X2HE-/1PE13.5,1P6
    1E15.5)
5105 FORMAT(/32H DIFFUSION COEF RATIOS TURBULENT/)
5110 FORMAT(/4X6HTESTRA10X4HAB1T11X4HAB2T11X4HAB3T11X4HAB4T11X4HAB5T11X
    14HAB6T11X4HAB7T/1PE13.5,1P7E15.5//20X4HBB1T11X4HBB2T11X4HBB3T11X4H
    2BB4T11X4HBB5T11X4HBB6T11X4HBB7T/1PE28.5,1P6E15.5//6X2HFK13X2HFA13X
    32HFB13X2HFC13X4HFEDA11X4HFEDB11X4HFEDC/1PE13.5,1P6E15.5)
5115 FORMAT(///37H SUBREGION VALUES AND WALL PARAMETERS)
5120 FORMAT(//11H  PRES TYPE37X9HPRES COEF/I8,1PE17.5,1P7E13.5//3X9HGEO
    1M SUBR6X6HOGIVEH9X6HOGIVEK10X2HRN13X2HXL11X6HCONEAN6X12HPRINTOUT I
    2NT/21X4H(FT)11X4H(FT)10X4H(FT)11X4H(FT)10X5H(RAD)/I9,1PE19.5,1P4E1
    35.5,I11)
5125 FORMAT(//11H CWALL COEF//6X2HO214X1HO13X2HN214X1HN13X2HNO13X3HNO+1
    12X2HE-9X11HH WALL COEF/(1PE13.5,1P7E15.5))
5130 FORMAT(18H1 INITIAL PROFILES//6X1HY10X5HC(O2)8X4HC(O)9X5HC(N2)8X4H
    1C(N)9X5HC(NO)8X6HC(NO+)7X5HC(E-)10X1HH12X1HU/4X4H(FT)97X10H(FT/SEC
    2)SQ4X8H(FT/SEC))
5135 FORMAT(1P10E13.5)
5140 FORMAT(15H1STATION VALUES3XI5,4I10//)
5145 FORMAT(7X1HX11X7HDELTA X8X6HZETA 19X8HRAD BODY4X12HBL MASS FLOW3X1
    14HSTREAMTUBE RAD3X9HWALL PRES7X7HRETHETA/5X4H(FT)11X4H(FT)11X4H(FT
    2)12X4H(FT)7X11H(LB SEC/FT)7X4H(FT)8X10H(LB/SQ FT)/1P4E15.7,1PE13.5
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     3,1P3E15.5//)
 5150 FORMAT(3X7HDELTA U6X7HDELTA H4X11HDELTA C(02)2X10HDELTA C(0)3X11HD
     1ELTA C(N2)2X10HDELTA C(N)3X11HDELTA C(NO)2X12HDELTA C(NO+)12H DELT
     2A C(E-)/4X4H(FT)9X4H(FT)9X4H(FT)9X4H(FT)9X4H(FT)9X4H(FT)9X
     34H(FT)9X4H(FT)/1P9E13.5//)
 5155 FORMAT(6X3HREX12X3HREW8X10HDELTA STAR8X5HTHETA6X13HNU/SQRT (REX)3X
     113HNU/SQRT (REW)5X7HC SUB F/5X4H     11X4H     11X4H(FT)12X4H(FT)/1P
     2E13.5,1P6E15.5//)
 5160 FORMAT(6X1HK10X5HC(02)8X4HC(0)9X5HC(N2)8X4HC(N)9X5HC(NO)7X6HC(NO+)
     18X5HC(E-)6X4HCSUM)
 5161 FORMAT (I8,1PE17.5,1P7E13.5)
 5165 FORMAT (1H16X1HK13X3HPSI13X1HY14X1HU14X1HT11X7HSMALL H11X1HH13X3HR
     1HO/16X13H(LB SEC/SQFT)6X4H(FT)9X8H(FT/SEC)8X7H(DEG K)6X11H(FT/SEC)
     2 SQ4X11H(FT/SEC) SQ3X13H(SLUGS/CU FT))
 5166 FORMAT(I9,1PE19.5,1P6E15.5)
 5170 FORMAT (1H16X1HK13X3HPSI13X1HY14X1HU14X1HT11X7HSMALL H11X1HH13X3HR
     1HO/17X11H(LB SEC/FT)7X4H(FT)9X8H(FT/SEC)8X7H(DEG K)6X11H(FT/SEC) S
     2Q4X11H(FT/SEC) SQ3X13H(SLUGS/CU FT))
 5171 FORMAT(I9,1PE19.5,1P6E15.5)
 5175 FORMAT (1H16X1HK8X13HELECTRON DENS7X4HMU L11X4HMU T11X4HTAUM/19X7H
     1PART/CC5X13H(LB SEC/SQFT)2X13H(LB SEC/SQFT)4X9H(LB/SQFT))
 5176 FORMAT (I9,1PE19.5,1P3E15.5)
 5180 FORMAT (1H148X24HSPECIES GENERATION TERMS//7X,1HK10X8HWDOT(02)8X7H
     1WDOT(0)7X8HWDOT(N2)8X7HWDOT(N)7X8HWDOT(NO)7X9HWDOT(NO+)6X8HWDOT(E-
     2)/16X15H(LB SEC/FT**4) 15H(LB SEC/FT**4) 15H(LB SEC/FT**4) 15H(LB
     3SEC/FT**4) 15H(LB SEC/FT**4) 15H(LB SEC/FT**4) 15H(LB SEC/FT)**4)
     4)
 5185 FORMAT (I9,1PE19.5,1P6E15.5)
 5190 FORMAT(1H146X27HPRODUCTION/DIFFUSION RATIO //)
 5195 FORMAT(7X1HK13X2HO214X1HO14X2HN213X1HN14X2HNO12X3HNO+13X2HE-/)
 5200 FORMAT(I8,1PE20.5,1P6E15.5)
C      PROBLEM PARAMETERS AND INDICATORS
 5800 TINF=FSHE/CPE
      WRITE OUTPUT TAPE 6,5000
      WRITE OUTPUT TAPE 6,5005,IALT,CPE,FSHE,GAMM,PE,RHOE,TINF,UINF
      WRITE OUTPUT TAPE 6,5010,(CE(I),I=1,NS)
      WRITE OUTPUT TAPE 6,5015
      WRITE OUTPUT TAPE 6,5020,RHOSTG,NSR
      DO 6020 I=1,NSR
      WRITE OUTPUT TAPE 6,5025,I
      IF(INDTYP(I)-6)6000,6015,6015
 6000 SHANGL=ATANF(ASR(I))
      IF(INDTYP(I)-1) 6003,6001,6003
 6001 WRITE OUTPUT TAPE 6,5038,SHANGL,STADIS,ASR(I),BSR(I),CSR(I),Z1R(I)
     1,Z2R(I)
      GO TO 6020
 6003 IF(EPSI) 6010,6005,6010
 6005 WRITE OUTPUT TAPE 6,5030,          SHANGL,STADIS,ASR(I),BSR(I),CSR
     1(I),Z1R(I),Z2R(I)
      GO TO 6020
 6010 WRITE OUTPUT TAPE 6,5035,          SHANGL,STADIS,ASR(I),BSR(I),CSR
     1(I),Z1R(I),Z2R(I)
      GO TO 6020
 6015 SHANGL=0.
      WRITE OUTPUT TAPE 6,5040,          SHANGL,STADIS,ASR(I),BSR(I),CSR
     1(I),Z1R(I),Z2R(I)
```

```
      SUBROUTINE STAOUT(KK)
 6020 CONTINUE
      WRITE OUTPUT TAPE 6,5045
      IF(INDSTR) 6025,6030,6035
 6025 WRITE OUTPUT TAPE 6,5050
      GO TO 6040
 6030 WRITE OUTPUT TAPE 6,5055
      GO TO 6040
 6035 WRITE OUTPUT TAPE 6,5060
 6040 WRITE OUTPUT TAPE 6,5065,L  ,NS,RN,Z1L,NPSI,JINPUT,RESTAR
      WRITE OUTPUT TAPE 6,5070,XS,Z1S,Z2S,DELTAX
      WRITE OUTPUT TAPE 6,5075,A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,FNDSSL
     1,FNDSSH,TIN
      WRITE OUTPUT TAPE 6,5080,ULOLIM,THPER,THPER,THPER,THPER,THPER,THPE
     1R,THPER
      WRITE OUTPUT TAPE 6,5085,EPSI,EPSIU,EPSIC,EPSIC,EPSIC,EPSIC,EPSIC,
     1EPSIH,EPSIT
      WRITE OUTPUT TAPE 6,5090,FLELIN,FLETIN,PRALIN,PRATIN,SCHLIN,SCHTIN
      WRITE OUTPUT TAPE 6,5095
      WRITE OUTPUT TAPE 6,5100,(DKDL(1,I),I=1,NS)
      WRITE OUTPUT TAPE 6,5105
      WRITE OUTPUT TAPE 6,5100,(DKDT(1,I),I=1,NS)
      WRITE OUTPUT TAPE 6,5110,TESTRA,AB1T,AB2T,AB3T,AB4T,AB5T,AB6T,AB7T
     1,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,FK,FA,FB,FC,FEDA,FEDB,FEDC
      RETURN
C     SUBREGION VALUES
 6041 WRITE OUTPUT TAPE 6,5115
      WRITE OUTPUT TAPE 6,5120,INDP,(P(I),I=1,8),INDR,OGIVEH,OGIVEK,RN,X
     1L,CONEAN,INDPRI
      WRITE OUTPUT TAPE 6,5125,((CC(J,I),I=1,NS),HH(J),J=1,5)
      WRITE OUTPUT TAPE 6,5130
      DO 6045 N=1,LP2
 6045 WRITE OUTPUT TAPE 6,5135,Y(N),(C(N,I),I=1,NS),FH(N),U(N)
      RETURN
C
C     STATION VALUES
C
 6046 IF(KK-9) 60465,6048,6048
60465 IPRINT=IPRINT+1
 6047 IF(IPRINT-INDPRI) 6170,6048,6048
 6048 WRITE OUTPUT TAPE 6,5140,JS,IDEL,KK,IPRINT,INDPRI
      IF(EPSI) 6055,6050,6055
 6050 FMBL=PSI(L)
      DIN2=PSI(L)/(RHOE*UINF)
      GO TO 6080
 6055 AREA=0.0
      DO 6075 I=1,L
      IF(I-1) 6060,6065,6060
 6060 IF(I-L) 6070,6065,6070
 6065 AREA=AREA+(RS+Y(I)*COSF(THETAT))*.5
      GO TO 6075
 6070 AREA=AREA+(RS+Y(I)*COSF(THETAT))
 6075 CONTINUE
      CONSTA=6.2831852/RS
      FMBL=AREA*CONSTA*DELTAP
      DIN2=SQRTF(FMBL/(3.1415926*RHOE*UINF))
 6080 AREA1=0.0
```

```
      DO 6100 I=2,L
      IF(I-2) 6085,6090,6085
 6085 IF(I-L) 6095,6090,6095
 6090 AREA1=AREA1+(U(L)-U(I))*.5
      GO TO 6100
 6095 AREA1=AREA1+(U(L)-U(I))
 6100 CONTINUE
      AREA1=AREA1+U(L)-.6667*AU12*SQRTF(DELTAP)-.5*BU12*DELTAP
      DO 303 N=1,LP2
  303 BLOCK(N)=U(N)
      CALL CONPRG(9)
      YTHU=YTH
      DO 313 N=1,LP2
  313 BLOCK(N)=FH(N)
      CALL CONPRG(9)
      YTHH=YTH
      DO 323 I=1,NS
      DO 323 N=1,LP2
      BLOCK(N)=C(N,I)
      CALL CONPRG(9)
  323 YTHC(I)=YTH
      THETA=AREA1/RS*DELTAP/(RHO(L)*U(L)**2)
      RETHET=(RHO(L)*U(L)*THETA)/FMUL(L)
      REX=(RHO(L)*U(L)*X)/FMUL(L)
      REW=(RHO(1)*U(L)*X)/FMUL(1)
      IF(FH(1)-FH(2)) 440,400,440
  400 DHDP12=0
      GO TO 440
  440 DO 540 I=1,NS
      IF(C(1,I)-C(2,I)) 540,500,540
  500 DCDP12(I)=0
      GO TO 540
  540 CONTINUE
      GARB=0
      DO 560 I=1,NS
  560 GARB=GARB+FSHI(1,I)*DKDL(1,I)*.5* AAU*AC12(I)
      FNUREW=X*RS/SQRTF(REW)*(.5*AAU*AH12+FLEWL(1)*GARB)/(FH
     1(L)-FH(1))
      FNUREX=FNUREW*SQRTF(REW/REX)
      DESTAR=Y(L)-(PSI(L)/RHO(L)/U(L)/RS)
      CSUB=TAUM(1)/(.5*RHO(L)*U(L)**2)
      WRITE OUTPUT TAPE 6,5145,X,DELTAX,Z1,RSM,FMBL,DIN2,PRSAVE,RETHET
      WRITE OUTPUT TAPE 6,5150,YTHU,YTHH,(YTHC(I),I=1,NS)
      WRITE OUTPUT TAPE 6,5155,REX,REW,DESTAR,THETA,FNUREX,FNUREW,CSUB
      WRITE OUTPUT TAPE 6,5160
      DO 6108 N=1,LP2
      CSUM=0.0
      DO 6106 I=1,NS
 6106 CSUM=CSUM+C(N,I)
 6108 WRITE OUTPUT TAPE 6,5161,N,(C(N,I),I=1,NS),CSUM
      IF(EPS1) 6120,6110,6120
 6110 WRITE OUTPUT TAPE 6,5165
      DO 6115 N=1,LP2
 6115 WRITE OUTPUT TAPE 6,5166,N,PSI(N),Y(N),U(N),T(N),FSH(N),FH(N),RHO(
     1N)
      GO TO 6130
```

```
 6120 WRITE OUTPUT TAPE 6,5170
      DO 6125 N=1,LP2
 6125 WRITE OUTPUT TAPE 6,5171,N,PSI(N),Y(N),U(N),T(N),FSH(N),FH(N),RHO(
     1N)
 6130 WRITE OUTPUT TAPE 6,5175
      DO 6135 N=1,LP2
      EDENS(N)=5.664696E26*C(N,7)*RHO(N)
 6135 WRITE OUTPUT TAPE 6,5176,N,EDENS(N),FMUL(N),FMUT1P(N),TAUM(N)
      EDEN12=5.664696E26*C12(7)*RHO12
      WRITE OUTPUT TAPE 6,6136,U12,FH12,RHO12,T12,Y12,FSH12,TAUM(2),EDEN
     112,(C12(I),I=1,NS)
 6136 FORMAT(1H03X5HU 1/210X6HFH 1/29X7HRHO 1/28X5HT 1/210X5HY 1/210X8HS
     1M H 1/26X8HTAUM 1/27X8HEDEN 1/2/1H 1P8E15.5/9H0C(I) 1/2/1H 1P7E15.
     25)
      IF(KK-9) 6138,6139,6139
 6138 IPRINT=0
 6139 IF(SENSE SWITCH 3) 6140,6150
 6140 WRITE OUTPUT TAPE 6,5180
      DO 6145 N=1,LP2
 6145 WRITE OUTPUT TAPE 6,5185,N,(WDOT(N,I),I=1,NS)
 6150 IF(SENSE SWITCH 5) 6155,6170
 6155 WRITE OUTPUT TAPE 6,5190
      WRITE OUTPUT TAPE 6,5195
      DO 6165 N=1,LP2
      DO 6160 I=1,NS
C     MODIFY DSCRIP FOR SUBSCRIPT VARIABLE WHEN CHANGED IN MP
 6160 PRDIRA(I)=WDOT(N,I)*DELTAP/RHO(N)/U(N)/RS/DSCRIP
 6165 WRITE OUTPUT TAPE 6,5200,N,(PRDIRA(I),I=1,NS)
 6170 RETURN
      END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
2087	04047	23203	55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	AAU	23204	55244
AB1T	32552	77450	AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	AB5T	32548	77444
AB6T	32547	77443	AB7T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426
ASK	32533	77425	AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222
B4T	32342	77126	B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	B81T	32102	76546
BB2T	32101	76545	BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541
BB7T	32096	76540	BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430
BU12	32014	76416	C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041
CM1	30143	72677	CM2	30133	72665	CM	30743	74027	CONEAN	29533	71535	CPE	29531	71533
CP	29532	71534	C	32013	76415	CSR	28930	70402	CS	29530	71532	CSUB	23214	55256
DCDP12	28920	70370	DEL	28910	70356	DELTAP	28909	70355	DELTAX	28908	70354	DELXOD	28907	70353
DELXST	28906	70352	DHDP12	28905	70351	DIST	28904	70350	DKDL	28903	70347	DKDT	28303	67217
DN2D02	27702	66066	DN2	27703	66067	DNO	27701	66065	D02	27700	66064	DSCRIP	27799	66063
DUDP12	27698	66062	EDENS	27697	66061	EPSIC	27636	65764	EPSIH	27635	65763	EPSI	27637	65765
EPSIT	27634	65762	EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757	FB	27630	65756
FC	27629	65755	FEDA	27628	65754	FEDB	27627	65753	FEDC	27626	65752	FH12	27565	65655
FHCALC	27564	65654	FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557	FH	27625	65751
FHS	27383	65367	FINO	27323	65273	FKPSI	27321	65271	FK	27322	65272	FLELIN	27260	65174
FLETIN	27259	65173	FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002	FLNOP	27018	64612
FLNO	27078	64706	FLO2	26958	64516	FL	27261	65175	FM	26898	64422	FMUL12	26828	64314
FMUL	26888	64410	FMUTIM	26827	64313	FMUTIP	26767	64217	FNDSSH	26707	64123	FNDSSL	26706	64122
FNUREW	23215	55257	FNUREX	23216	55260	FSH12	23210	55252	FSHE	26645	64025	FSHI12	26044	62674
FSHI	26644	64024	FSHP	26034	62662	FSH	26705	64121	FSKRA	26032	62660	FSKRB	26022	62646
FSKRC	26012	62634	FSKRD	26002	62622	FSKRE	26001	62621	FSKRF	26000	62620	FSKRK	25999	62617
FSK	26035	62661	FSME	25989	62605	FSMNOP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604
FSMO	25985	62601	GAMM	25984	62600	HE	25983	62577	HH	25982	62576	IALT	25977	62571
IDEL	25976	62570	INDCOC	25975	62567	INDLAS	25965	62555	INDPRI	25954	62542	INDP	25955	62543
INDPS	25953	62541	INDR	25903	62457	INDSTP	25902	62456	INDSTR	25901	62455	INDTYP	25900	62454
IPRINT	23213	55255	JBYCTR	23211	55253	JINPUT	25890	62442	JS	25889	62441	KS	25888	62440
LP2	25886	62436	L	25887	62437	NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433
NS	25884	62434	OGIVEH	25882	62432	OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322
PRAL	25870	62416	PRATIN	25749	62225	PRAT	25809	62321	PRDIRA	25748	62224	PRDS	25688	62130
PRP	25687	62127	PR	25871	62417	PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305
PS1	25225	61241	PSITCU	25165	61115	PS	25685	62125	QW	25164	61114	RESTAR	25162	61112
RETHET	23219	55263	REW	23217	55261	REX	23218	55262	RHO12	25040	60720	RHOCAL	25101	61015
RHOE	25041	60721	RHO	25161	61111	RHOSTG	25039	60717	RHOU12	23205	55245	RN	25038	60716
RNS	25037	60715	R	25163	61113	RSC	24936	60632	RSM	24985	60631	RS	24987	60633
SCHLIN	24984	60630	SCHTIN	24983	60627	SCL	24982	60626	SCT	24922	60532	SHANGL	24862	60436
SIGMA2	24861	60435	SIGMAH	24801	60341	SIGMAU	24741	60245	STADIS	24681	60151	STRLL	23207	55247
STRUL	23206	55246	T12	23209	55251	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664
THETAT	24499	57663	THPER	24498	57662	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644
TITLE3	24472	57630	TM	24460	57614	T	24680	60150	TVN2	24400	57520	TVNOP	24398	57516
TVNO	24399	57517	TV02	24397	57515	U12	24336	57420	UCALC	24335	57417	US	24275	57323
UINF	24274	57322	ULOLIM	24273	57321	UM1	24212	57224	UM2	24152	57130	UM	24272	57320
U	24396	57514	US	24092	57034	WDOT	24032	56740	XI	23431	55607	XL	23430	55606
XLS	23429	55605	XRN	23379	55523	X	23432	55610	XS	23378	55522	XU12	23377	55521
Y12	23208	55250	YCALC	23316	55424	Y	23376	55520	YTHC	23255	55327	YTH	23256	55330

YTHU 23245 55315	Z1L 23243 55313	Z1R 23242 55312	Z1 23244 55314	Z1S 23232 55300	
Z2R 23230 55276	Z2 23231 55277	Z2S 23220 55264			

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
AREA1	2086	04046	AREA	2085	04045	CONSTA	2084	04044	CSUM	2083	04043	DESTAR	2082	04042
DIN2	2081	04041	EDEN12	2080	04040	FMBL	2079	04037	GARB	2078	04036	I	2077	04035
N	2076	04034	THETA	2075	04033	TINF	2074	04032	YTHH	2073	04031			

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)4S8	5000	04015	8)4SD	5005	04003	8)4SI	5010	03742	8)4SN	5015	03723	8)4SS	5020	03716
8)4T1	5025	03704	8)4T6	5030	03651	8)4TB	5035	03643	8)4TE	5038	03635	8)4TG	5040	03630
8)4TL	5045	03622	8)4TQ	5050	03607	8)4TV	5055	03571	8)4U4	5060	03555	8)4U9	5065	03541
8)4UE	5070	03506	8)4UJ	5075	03467	8)4U0	5080	03435	8)4UT	5085	03407	8)4V2	5090	03361
8)4V7	5095	03331	8)4VC	5100	03322	8)4VH	5105	03307	8)4VM	5110	03300	8)4VR	5115	03226
8)500	5120	03216	8)505	5125	03154	8)50A	5130	03133	8)50F	5135	03103	8)50K	5140	03101
8)50P	5145	03073	8)50U	5150	03031	8)513	5155	02764	8)518	5160	02734	8)519	5161	02717
8)51D	5165	02713	8)51E	5166	02657	8)51I	5170	02653	8)51J	5171	02620	8)51N	5175	02614
8)510	5176	02570	8)51S	5180	02564	8)521	5185	02510	8)526	5190	02504	8)52B	5195	02475
8)52G	5200	02463	8)5V0	6136	02457									

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	2062	04016	2)	1287	02407	3)	1294	02416	6)	1300	02424	C)G0	2067	04023
C)G2	2068	04024	C)G3	2069	04025	C)102	2070	04026	C)200	2071	04027	C)201	2072	04030
E)7	147	00223	E)D	235	00353	E)F	250	00372	E)10	606	01136			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ATAN	2	00002	CONPRG	5	00005	COS	3	00003	SQRT	4	00004	(FIL)	1	00001
(STH)	0	00000												

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ATAN CONPRG COS SQRT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
5800	59	00035	6000	75	00162	6001	77	00174	6003	80	00225	6005	81	00231
6010	84	00260	6015	87	00307	6020	90	00337	6025	93	00354	6030	95	00363
6035	97	00373	6040	98	00401	6041	126	00763	6045	143	01104	6046	151	01137
27697	152	01143	6047	153	01146	6048	154	01153	6050	157	01201	6055	160	01212
6060	163	01224	6065	164	01231	6070	166	01246	6075	167	01260	6080	171	01310
6085	174	01322	6090	175	01327	6095	177	01336	6100	178	01342	303	181	01372
313	185	01407	323	192	01440	400	198	01515	440	200	01523	500	202	01534
540	204	01542	560	207	01556	6106	226	02002	6108	227	02010	6110	234	02042
6115	236	02053	6120	239	02103	6125	241	02114	6130	243	02143	6135	246	02162
6138	256	02250	6139	257	02252	6140	258	02254	6145	260	02276	6150	266	02315
6155	267	02317	6160	271	02344	6165	272	02361	6170	278	02403			

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      SUBROUTINE STEPSZ
      SUBROUTINE STEPSZ
C
      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
     4CSR,DCDP12,DEL,DELTAP,DELTAX,DELXOD,DELXST,DHDP12,DIST,DKDL,
     5DKDT,DN2,DN2DO2,DNO,DO2,DSCRIP,DUDP12,EDENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
     7FEDC,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
      COMMON FIND,FK,FKPSI,FL,FLELIN,FLETIN,FLEWL,FLEWT,
     1FLN2,FLND,FLNDP,FLO2,FM,FMUL,FMUL12,FMUT1M,FMUT1P,FNDSSH,
     2FNDSSL,FSH,FSHE,FSHI,FSHI12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMND,FSMNCP,FSMD,GAMM,HE,
     4HH,IALT,IDEL,INDCDO,INDLAS,INDP,INDPRI,INDPS,INDR,
     5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     6DGIVEH,DGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
      COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITOU,QW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STAD(S,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVNC,TVNDP,TVO2,U,U12,UCALC,UE,UINF,ULDLIM,UM,UM1,
     6UM2,US,WDOT,X,XI,XL,XLS,XPN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHO,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
C
      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
     4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
     5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLND(60),
     6FLNDP(60),FLO2(60),FM(10),FMUL(60),FMUT1M(60)
      DIMENSION FMUT1P(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCDO(10),
     2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)
C
   50 IF((DEL-2) 100,200,300
  100 DO 105 N=1,LP2
      US(N)=U(N)
      U(N)=UP(N)
      UM1(N)=UM(N)
      FHS(N)=FH(N)
      FH(N)=FHM(N)
      DO 105 I=1,NS
      CS(N,I)=C(N,I)
  105 C(N,I)=CM(N,I)
      RSSS=RS
```

```
      IF(SENSE SWITCH 2)106,108
  106 CALL STACUT(3)
  108 DO 114 N=1,LP2
      IF(UM(N)) 116,111,111
  111 DO 112 I=1,NS
      IF(CM(N,I)) 118,112,112
  112 CONTINUE
      IF(FHM(N)) 118,113,113
  113 IF(T(N))118,114,114
  114 CONTINUE
      IF(SENSE SWITCH 5) 1142,1162
 1142 DO 116 N=1,L
      IF((UM(N+1)-UM(N))/UM(N+1)+.05) 118,116,116
  116 CONTINUE
 1162 IF(X+3.1*DELTAX-XL) 120,130,130
  118 PRINT 119,N,X,DELTAX
  119 FORMAT(3X23HSTEP SIZE CRITERIA   N=I3,5H   X=1PE13.5,10H   DELTAX=
     11PE13.5)
      NCCUN7=NCCUN7+1
      IF(NCCUN7-7) 515,600,600
  120 RS=RSM
  125 IDEL=IDEL+1
      X=X+DELTAX
      INDSTP=2
      RETURN
  130 X=X+DELTAX
      RS=RSM
      INDSTP=3
      RETURN
  200 IF (SENSE SWITCH 2) 202,206
  202 DO 205 N=1,LP2
      U(N)=UM(N)
      FF(N)=FHM(N)
      DO 205 I=1,NS
  205 C(N,I)=CM(N,I)
      CALL STACUT(3)
  206 DO 210 N=1,LP2
      UM2(N)=US(N)
      UM2(N)=UM(N)
      FF(N)=FFS(N)
      FHM2(N)=FHM(N)
      DO 210 I=1,NS
      C(N,I)=CS(N,I)
  210 CM2(N,I)=CM(N,I)
      RS=RSSS
      RSMS=RSM
      DELTAX=2.0*DELTAX
      X=X-DELTAX
      GO TO 125
  300 DO 320 N=1,LP2
      IF(ABSF((UM2(N)-UM(N))/UM2(N))-FNDSSL) 310,310,400
  310 IF(ABSF((FHM2(N)-FHM(N))/FHM2(N))-FNCSSL) 320,320,400
  320 CONTINUE
      IF(A2) 341,325,325
  325 DO 340 I=1,NS
      DO 340 N=1,LP2
```

```
  330 IF(ABSF((CM2(N,I)-CM(N,I))/CM2(N,I))-ENDSSL) 340,340,400
  340 CONTINUE
  341 INDSSS=1
      IF(SENSE SWITCH 6) 343,346
  343 PRINT 345,DELTAX,X
  345 FORMAT(20H DELTAX INCREASED TO1PE15.8,7H      X=1PE15.8)
  346 DO 350 N=1,LP2
      U(N)=UM(N)
      EP(N)=EPM(N)
      DO 350 I=1,NS
  350 C(N,I)=CM(N,I)
  352 DO 360 N=2,L
      IF(INDSSS) 360,365,365
  360 RSMRS=RS*RHO(N)*UM1(N)*RS
      GO TO 370
  365 RSMRS=RS*RHO(N)*U(N)*RS
  370 SIGMAL(N)=RSMRS*(A1L*FMUL(N)+A1T*(FMUT1P(N)+FMUT1M(N))*.5)
      SIGMAH(N)=RSMRS*(A4L*FMUL(N)/PRAL(N)+A4T*(FMUT1P(N)+FMUT1M(N))*.5/
     1PRAT(N))
      IF(A2) 3708,3705,3705
 3705 SIGMAC(N)=RSMRS*(A3L*FMUL(N)*DKDL(N,1)/SCL(N)+A3T*.5*(FMUT1P(N)+FM
     1UT1M(N))*DKDT(N,1)/SCT(N))
 3708 IF (SENSE SWITCH 2) 371,373
  371 WRITE OUTPUT TAPE 6,372,N,SIGMAU(N),SIGMAC(N),SIGMAH(N)
  372 FORMAT(5X13,1P3E13.5)
  373 IF(SIGMAU(N)) 374,375,374
  374 IF(DELTAX-DELTAP**2/2.0/SIGMAU(N)/1.00001) 375,375,485
  375 IF(A2) 377,3755,3755
 3755 IF(SIGMAC(N)) 376,377,376
  376 IF(DELTAX-DELTAP**2/2.0/SIGMAC(N)/1.00001) 377,377,485
  377 IF(SIGMAH(N)) 378,380,378
  378 IF(DELTAX-DELTAP**2/2.0/SIGMAH(N)/1.00001) 380,380,485
  380 CONTINUE
      JS=JS+1
  385 CALL STADLT(3)
  390 NCCLNT=0
      JBYCTR=JBYCTR+2
      GO TO 130
  400 DO 420 N=1,LP2
      IF(ABSF((UM2(N)-UM(N))/UM2(N))-ENDSSH) 410,410,470
  410 IF(ABSF((EPM2(N)-EPM(N))/EPM2(N))-ENDSSH) 420,420,470
  420 CONTINUE
      IF(A2) 445,425,425
  425 DO 440 I=1,NS
      DO 440 N=1,LP2
  430 IF(ABSF((CM2(N,I)-CM(N,I))/CM2(N,I))-ENDSSH) 440,440,470
  440 CONTINUE
  445 INDSSS=-1
      DELTAX=.5*DELTAX
      DO 460 N=1,LP2
      U(N)=UM2(N)
      EP(N)=EPM2(N)
      DO 460 I=1,NS
  460 C(N,I)=CM2(N,I)
      RSM=RSMS
      GO TO 352
```

```
470 IF(JBYCTR-JINPUT)445,445,500
485 IF(SENSE SWITCH 6)486,500
486 PRINT 490
490 FORMAT(5X22HSTABILITY RECD HALVING)
500 IF(SENSE SWITCH 6)501,506
501 PRINT 505,DELTAX,X
505 FORMAT(20H DELTAX DEC TO 1/4  1PE15.8,7H      X=1PE15.8)
506 ACCUM7=ACCUM7+1
    IF(ACCUM7-7)507,600,600
507 DO 510 N=1,LP2
    U(N)=UP(N)
    FH(N)=FHM(N)
    DO 510 I=1,NS
510 C(N,I)=CM(N,I)
    CALL STACLT(3)
515 DO 520 N=1,LP2
    U(N)=US(N)
    FH(N)=FHS(N)
    DO 520 I=1,NS
520 C(N,I)=CS(N,I)
    RS=RSSS
    X=X-.75*DELTAX
    DELTAX=.25*DELTAX
    INDSTP=1
    RETURN
600 PRINT 602
602 FORMAT(2X22HDELTA X HALVED 7 TIMES)
    PAUSE 603
    GO TO 515
    END(1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
801	01441	23210	55252

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	AB1T	32552	77450
AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	AB5T	32548	77444	AB6T	32547	77443
AB7T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426	ASR	32533	77425
AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222	B4T	32342	77126
B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	BB1T	32102	76546	BB2T	32101	76545
BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541	BB7T	32096	76540
BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430	BU12	32014	76416
C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041	CM1	30143	72677
CM2	30133	72665	CM	30743	74027	CONEAN	29533	71535	CPE	29531	71533	CP	29532	71534
C	32013	76415	CSR	28930	70402	CS	29530	71532	CSUB	23214	55256	DCDP12	28920	70370
DEL	28910	70356	DELTAP	28909	70355	DELTAX	28908	70354	DELXOD	28907	70353	DELXST	28906	70352
DHDP12	28905	70351	DIST	28904	70350	DKDL	28903	70347	DKDT	28303	67217	DN2D02	27702	66066
DN2	27703	66067	DNO	27701	66065	DO2	27700	66064	DSCRIP	27699	66063	DUDP12	27698	66062
EDENS	27697	66061	EPSIC	27636	65764	EPSIH	27635	65763	EPSI	27637	65765	EPSIT	27634	65762
EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757	FB	27630	65756	FC	27629	65755
FEDA	27628	65754	FEDB	27627	65753	FEDC	27626	65752	FH12	27565	65655	FHCALC	27564	65654
FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557	FH	27625	65751	FHS	27383	65367
FINO	27323	65273	FKPSI	27321	65271	FK	27322	65272	FLELIN	27260	65174	FLETIN	27259	65173
FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002	FLNOP	27018	64612	FLNO	27078	64706
FLO2	26958	64516	FL	27261	65175	FM	26898	64422	FMUL12	26828	64314	FMUL	26888	64410
FMUTIM	26827	64313	FMUT1P	26767	64217	FNDSSH	26707	64123	FNDSSL	26706	64122	FNUREW	23215	55257
FNUREX	23216	55260	FSHE	26645	64025	FSHI12	26044	62674	FSHI	26644	64024	FSHP	26034	62662
FSH	26705	64121	FSKRA	26032	62660	FSKRB	26022	62646	FSKRC	26012	62634	FSKRD	26002	62622
FSKRE	26001	62621	FSKRF	26000	62620	FSKRK	25999	62617	FSK	26033	62661	FSME	25989	62605
FSMNOP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604	FSMO	25985	62601	GAMM	25984	62600
HE	25983	62577	HH	25982	62576	IALT	25977	62571	IDEL	25976	62570	INDCOO	25975	62567
INCLAS	25965	62555	INDPRI	25954	62542	INDP	25955	62543	INDPS	25953	62541	INDR	25903	62457
INDSTP	25902	62456	INDSTR	25901	62455	INDTYP	25900	62454	IPRINT	23213	55255	JBYCTR	23211	55253
JINPUT	25890	62442	JS	25889	62441	KS	25888	62440	LP2	25886	62436	L	25887	62437
NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433	NS	25884	62434	OGIVEH	25882	62432
OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322	PRAL	25870	62416	PRATIN	25749	62225
PRAT	25809	62321	PRDIRA	25748	62224	PROS	25688	62130	PRP	25687	62127	PR	25871	62417
PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305	PSI	25225	61211	PSITCU	25165	61115
PS	25685	62125	QW	25164	61114	RESTAR	25162	61112	RETHET	23219	55263	REW	23217	55261
REX	23218	55262	RHO12	25040	60720	RHOCAL	25101	61015	RHOE	25041	60721	RHO	25161	61111
RHOSTG	25039	60717	RN	25038	60716	RNS	25037	60715	R	25163	61113	RSC	24986	60632
RSM	24985	60631	RS	24987	60633	SCHLIN	24984	60630	SCHTIN	24983	60627	SCL	24982	60626
SCT	24922	60532	SHANGL	24862	60436	SIGMAC	24861	60435	SIGMAH	24801	60341	SIGMAU	24741	60245
STADIS	24681	60151	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664	THETAT	24499	57663
THPER	24458	57662	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644	TITLE3	24472	57630
TM	24460	57614	T	24680	60150	TVN2	24400	57520	TVNOP	24398	57516	TVNO	24399	57517
TVO2	24397	57515	U12	24336	57420	UCALC	24335	57417	UE	24275	57323	UINF	24274	57322
ULOLIM	24273	57321	UM1	24212	57224	UM2	24152	57130	UM	24272	57320	U	24396	57514
US	24092	57034	WDOT	24032	56740	XI	23431	55607	XL	23430	55606	XLS	23429	55605
XRN	23379	55523	X	23432	55610	XS	23378	55522	XU12	23377	55521	YCALC	23316	55424
Y	23376	55520	YTHC	23255	55327	YTH	23256	55330	YTHU	23245	55315	Z1L	23243	55313
Z1R	23242	55312	Z1	23244	55314	Z1S	23232	55300	Z2R	23230	55276	Z2	23231	55277

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
INDSSS	800	01440	I	799	01437	NCOUNT	798	01436	N	797	01435	RSMRS	796	01434
RSMS	795	01433	RSSS	794	01432									

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)3N	119	01415	8)A?	345	01401	8)8K	372	01370	8)FA	490	01365	8)FP	505	01360
8)IC	602	01347												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	782	01416	2)	719	01317	3)	726	01326	6)	733	01335	C)C9	786	01422
C)100	787	01423	C)101	788	01424	C)200	789	01425	C)201	790	01426	C)202	791	01427
C)203	792	01430	C)204	793	01431	D)132	611	01143	D)133	711	01307	D)33I	710	01306
D)4CQ	132	00204	D)43D	664	01230	D)60Q	131	00203	D)70Q	130	00202	D)73I	709	01305
E)9	66	00102	E)E	85	00125	E)M	117	00165	E)10	272	00420	E)1H	290	00442
E)1J	304	00460	E)2P	563	01063	E)3D	666	01232						

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
STAOUT	0	00000	(FIL)	2	00002	(SPH)	1	00001	(STH)	3	00003			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

STAOUT (FIL) (SPH) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
50	16	00015	100	17	00021	105	25	00051	106	28	00065	108	29	00067
111	31	00107	112	33	00122	113	35	00136	114	36	00144	1142	38	00153
116	40	00171	1162	41	00173	118	42	00205	120	46	00232	125	47	00234
130	52	00250	200	57	00263	202	58	00265	205	62	00305	206	64	00317
210	71	00345	300	77	00370	310	79	00407	320	80	00424	325	82	00432
330	84	00447	340	85	00467	341	86	00476	343	88	00502	346	90	00511
350	94	00531	352	95	00541	360	97	00554	365	99	00564	370	100	00573
3705	103	00635	3708	104	00660	371	105	00662	373	107	00676	374	108	00700
375	109	00714	3755	110	00720	376	111	00722	377	112	00736	378	113	00740
380	114	00754	385	116	00765	390	117	00767	400	120	00775	410	122	01015
420	123	01031	425	125	01040	430	127	01052	440	128	01072	445	129	01103
460	135	01130	470	138	01144	485	139	01151	486	140	01153	500	141	01156
501	142	01160	506	144	01167	507	146	01176	510	150	01216	515	152	01235
520	156	01255	600	163	01310									

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      SUBROUTINE UCSTRE

      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
     4CSR,DCDP12,DEL,DELTAP,DELTAX,DELXOD,DELXST,DHDP12,DIST,DKDL,
     5DKDT,DN2,DN2002,DNO,DO2,DSCRIP,DUDP12,EDENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
     7FEDC,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
      COMMON FINU,FK,FKPSI,FL,FLELIN,FLETIN,FLEWL,FLEWT,
     1FLN2,FLNO,FLNOP,FLO2,FM,FMUL,FMUL12,FMUT1M,FMUT1P,FNDSSH,
     2FNDSSL,FSH,FSHE,FSHI,FSHI12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMNO,FSMNOP,FSMO,GAMM,HE,
     4HH,IALT,IDEL,INDCOC,INDLAS,INDP,INDPRI,INDPS,INDR,
     5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     6OGIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
      COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVNO,TVNOP,TVO2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
     6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
     1,FSH12,T12,Y12,STRLL,STRUL

      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
     4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
     5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLNO(60),
     6FLNOP(60),FLO2(60),FM(10),FMUL(60),FMUT1M(60)
      DIMENSION FMUT1P(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCOC(10),
     2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)

      IF(INDSTR) 5000,50,2
    2 GO TO (3,4,5,3,5),INDR
    3 THETAT=1.5707963-(ALPHA+XRN)
      GO TO 7
    4 THETAT=CONEAN
      GO TO 7
    5 THETAT=0.0
    7 IF(EPSI) 10,9,10
    9 TWOPI=1.0
      RSTPE=RS
```

```
      GO TO 12
   10 TWOPI=6.2831853
      RSIME=1.0
   12 FMBL=0.0
      DO 15 N=2,L
   15 FMBL=FMBL+2.0*Y(N)
      FMBL=(FMBL+Y(1)-Y(L))*TWOPI*COSF(THETAT)*DELTAP/RS+TWOPI*RSIME*PSI
     1(L)
      DIN2=SQRTF(FMBL/RHOE/UINF/3.1415926)
      IF(DIN2-RS) 19,19,16
   16 PRINT 17,DIN2,RS,FMBL,THETAT
   17 FORMAT(7H  DIN2=1PE13.5,4HRS =1PE13.5,1P2E13.5)
      DIN2=.9*RS
   19 DO 20 N=1,10
      IF(DIN2-Z2K(N))25,25,20
   20 CONTINUE
      STOP 21
   25 IF(INDTYP(1)-1)29,26,29
   26 Z1A=0.0
      THETA=1.5707963
      GO TO 40
   29 IF(INDTYP(N)-6)30,35,35
   30 Z1A=(DIN2-BSR(N))/ASR(N)
      THETA=ATANF(ASR(N))
      GO TO 40
   35 Z1A=ASR(N)+BSR(N)*(DIN2-CSR(N))**2
      THETA=ATANF(.5/BSR(N)/(DIN2-CSR(N)))
   40 DIST=SQRTF((Z1A-Z1)**2+(DIN2-Z2)**2)
      FM1=UINF/49.9/SQRTF(1.8*FSHE/CPE)
      PRDS=PE*(2.0*GAMM*(FM1*SINF(THETA))**2-GAMM+1.0)/(GAMM+1.0)
      UDS=SQRTF(1.0-(4.0*(FM1**2*(SINF(THETA))**2-1.0)*(GAMM*(FM1*SINF
     1(THETA))**2+1.0))/((GAMM+1.0)**2*FM1**4*(SINF(THETA))**2))*UINF
      SCOMP=(Z1-Z1A)/DIST
      UESTAR=UDS
      WRITE OUTPUT TAPE 6,42,THETA,PRDS,Z1A,DIN2,UDS
   42 FORMAT(14H1 SHOCK ANGLE=1PE13.5,7H  PRDS=1PE13.5,6H  Z1A=1PE13.5,7
     1H  DIN2=1PE13.5,6H  UDS=1PE13.5)
      GO TO 52
   50 UESTAR=UE
   52 NCOUNT=0
      WRITE OUTPUT TAPE 6,55
   55 FORMAT(6X3HXOD10X4HZ10D10X1HU11X4HC(N)8X5HC(NO)8X6HC(NO+)8X5HC(E-)
     110X1HT11X3HRHO10X2HNE/)
      K=1
      IF(INDSTR) 5555,56,58
   56 XOD=XS+DELXST
      GO TO 60
   58 XOD=DELXST
      Z1OD=Z1A+SCOMP*DELXST
   60 U(L+3)=UESTAR
      DO 65 I=1,NS
   65 C(L+3,I)=CE(I)
      FH(L+3)=FHE
      PSI(L+3)=PSI(L+2)+DELTAP
   70 INDFOD=-1
      DELXOD=DELXST
```

```
  100 CALL PRTERH(XOO,L+3,L+3,K)
      IF(A2) 1005,1005,1003
 1003 CALL WOOTRT(L+3,L+3)
 1005 US(L+3)=U(L+3)
      UM1(L+3)=U(L+3)-PRP/RHO(L+3)*DELXOO/U(L+3)
      U(L+3)=UM1(L+3)
      DO 1020 I=1,NS
      CS(L+3,I)=C(L+3,I)
      CM1(I)    =C(L+3,I)+DELXOO*WDOT(L+3,I)/U(L+3)/RHO(L+3)
 1020 C(L+3,I)=CM1(I)
      XOO=XOO+DELXOO
      IF(INDSTR)5555,1022,1021
 1021 Z1OO=Z1OO+SCOMP*DELXOO
 1022 CALL PRTERH(XOO,L+3,L+3,K)
      IF(A2) 1025,1025,1023
 1023 CALL WOOTRT(L+3,L+3)
 1025 UM2(L+3)=U(L+3)-PRP/RHO(L+3)*DELXOO/U(L+3)
      U(L+3)=US(L+3)
      DO 2030 I=1,NS
      CM2(L+3,I)=C(L+3,I)+DELXOO*WDOT(L+3,I)/U(L+3)/RHO(L+3)
 2030 C(L+3,I)=CS(L+3,I)
      DELXOO=2.0*DELXOO
      CALL PRTERH(XOO,L+3,L+3,K)
      IF(A2) 2035,2035,2033
 2033 CALL WOOTRT(L+3,L+3)
 2035 UM(L+3)=U(L+3)-PRP/RHO(L+3)*DELXOO/U(L+3)
      DO 2040 I=1,NS
 2040 CM(L+3,I)=C(L+3,I)+DELXOO*WDOT(L+3,I)/U(L+3)/RHO(L+3)
      IF(ABSF((UM2(L+3)-UM(L+3))/UM2(L+3))-FNOSSL)2050,2050,2070
 2050 IF(A2) 2065,2052,2052
 2052 DO 2060 I=1,NS
      IF(ABSF((CM2(L+3,I)-CM(L+3,I))/CM2(L+3,I))-FNOSSL)2060,2060,2070
 2060 CONTINUE
 2065 IND22=0
      GO TO 2110
 2070 IF(ABSF((UM2(L+3)-UM(L+3))/UM2(L+3))-FNOSSH)2080,2080,2100
 2080 IF(A2) 2095,2082,2082
 2082 DO 2090 I=1,NS
      IF(ABSF((CM2(L+3,I)-CM(L+3,I))/CM2(L+3,I))-FNOSSH)2090,2090,2100
 2090 CONTINUE
 2095 IND22=1
      GO TO 2110
 2100 XOO=XOO-.75*DELXOO
      IND22=-1
      IF(INOSTR) 5555,2105,2103
 2103 Z1OO=Z1OO-.75*DELXOO*SCOMP
 2105 DELXOO=.25*DELXOO
      GO TO 100
 2110 IF(INOSTR)5555,2120,2115
 2115 IF(Z1OO+SCOMP*DELXOO-Z1)2150,2130,2130
 2120 IF(XOO+DELXOO-X) 2145,2130,2130
 2130 UM(L+3)=UM1(L+3)
      DO 2140 I=1,NS
 2140 CM(L+3,I)=CM1(I)
      XOO=XOO-0.5*DELXOO
      IF(INOSTR) 5555,2143,2141
```

```
2141 Z1OD=Z1OD-.5*DELXOD*SCOMP
2143 DELXOD=0.5*DELXOD
     GO TO 2500
2145 IF(XOD+DELXOD-XLS(K)) 2150,2130,2130
2150 IF(IND22) 2500,2500,2170
2170 UM(L+3)=UM2(L+3)
     DO 2180 I=1,NS
2180 CM(L+3,I)=CM2(L+3,I)
     DELXOD=0.5*DELXOD
2500 IF(UM(L+3)-ULOLIM)2505,2510,2510
2505 UM(L+3)=ULOLIM
2510 IF(IND22) 3060,2600,3060
2600 FNE=RHO(L+3)*CM(L+3,7)*5.664696E26
     WRITE OUTPUT TAPE 6,3005,XOD,Z1OD,UM(L+3),(CM(L+3,I),I=4,NS),T(L+3
    1),RHO(L+3),FNE
3005 FORMAT (1H ,1P10E13.5)
3060 IF(INOSTR) 5555,3109,3460
3109 IF(K-KS)3120,3110,3110
3110 IF(ABSF(XOD-X)-.01*DELXOD)3500,3500,3115
3115 IF(XOD-X)3120,3500,3610
3120 XOD=XOD+DELXOD
3123 U(L+3)=UM(L+3)
     DO 3125 I=1,NS
3125 C(L+3,I)=CM(L+3,I)
     IF(INOSTR) 5555,3140,3130
3130 Z1OD=Z1OD+DELXOD*SCOMP
     GO TO 100
3140 IF(INDFOD)3150,3450,3400
3150 IF(ABSF(XOD-XLS(K))-.01*DELXOD)3200,3200,3155
3155 IF(XOD-XLS(K)) 100,3200,3300
3200 INDFOD=0
     GO TO 100
3300 DELXOD=DELXOD-(XOD-XLS(K))
     XOD=XLS(K)
     INDFOD=1
     GO TO 100
3400 XOD=XOD-DELXOD+DELXST
3450 K=K+1
     GO TO 70
3460 IF(ABSF(Z1OD-Z1)-.01*DELXOD*SCOMP)3500,3500,3470
3470 IF(Z1OD-Z1)3120,3500,3620
3500 IF(A2) 3510,3520,3520
3510 CALL CEOGE(9,L+3,L+3)
3520 RETURN
3610 DELXOD=DELXOD-(XOD-X)
     XOD=X
     GO TO 4000
3620 DELXOD=DELXOD-(Z1OD-Z1)/SCOMP
     XOD=XOD-(Z1OD-Z1)/SCOMP
     Z1OD=Z1
4000 CALL PRTERH(XOD,L+3,L+3,K)
     IF(A2) 4035,4035,4033
4033 CALL WDOTRT(L+3,L+3)
4035 UM(L+3)=U(L+3)-PRP/RHO(L+3)*DELXOD/U(L+3)
     DO 4040 I=1,NS
4040 CM(L+3,I)=C(L+3,I)+DELXOD*WDOT(L+3,I)/U(L+3)/RHO(L+3)
```

```
      SUBROUTINE UCSTRE

4503  IF(UM(L+3)-ULOLIM)4505,4510,4510
4505  UM(L+3)=ULOLIM
4511  FNE=RHO(L+3)*CM(L+3,7)*5.666696E26
      WRITE OUTPUT TAPE 6,3005,XOO,ZIOO,UM(L+3),(CM(L+3,I),I=4,NS),T(L+3
     1),RHO(L+3),FNE
      GO TO 3500
5000  UM(L+3)=UE
      DO 5010 I=1,NS
5010  CM(L+3,I)=CE(I)
      FM(L+3)=FME
      PSI(L+3)=PSI(L+2)+DELTAP
      RETURN
5555  STOP 5555
      END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
1131	02153	23205	55245

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	A81T	32552	77450
AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	AB5T	32548	77444	AB6T	32547	77443
AB7T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426	ASR	32533	77425
AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222	B4T	32342	77126
B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	BB1T	32102	76546	BB2T	32101	76545
BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541	BB7T	32096	76540
BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430	BU12	32014	76416
C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041	CM1	30143	72677
CM2	30133	72665	CM	30743	74027	CONEAN	29533	71535	CPE	29531	71533	CP	29532	71534
C	32613	76415	CSR	28930	70402	CS	29530	71532	CSUB	23214	55256	DCDP12	28920	70370
DEL	28910	70356	DELTAP	28909	70355	DELTAX	28908	70354	DELXOD	28907	70353	DELXST	28906	70352
DHDP12	28905	70351	DIST	28904	70350	DKDL	28903	70347	DKDT	28303	67217	DN2DO2	27702	66066
DN2	27703	66067	DNO	27701	66065	DO2	27700	66064	DSCRIP	27699	66063	DUDP12	27698	66062
EDENS	27697	66061	EPSIC	27636	65764	EPSIM	27635	65763	EPSI	27637	65765	EPSIT	27634	65762
EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757	FB	27630	65756	FC	27629	65755
FEDA	27628	65754	FEDB	27627	65753	FEDC	27626	65752	FH12	27565	65655	FHCALC	27564	65654
FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557	FH	27625	65751	FHS	27383	65367
FINO	27323	65273	FKPSI	27321	65271	FK	27322	65272	FLELIN	27260	65174	FLETIN	27259	65173
FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002	FLNOP	27018	64612	FLNO	27078	64706
FLO2	26958	64516	FL	27261	65175	FM	26898	64422	FMUL12	26820	64314	FMUL	26888	64410
FMUTIM	26827	64313	FMUTIP	26767	64217	FNDSSH	26707	64123	FNDSSL	26706	64122	FNUREW	23215	55257
FNUREX	23216	55260	FSH12	23210	55252	FSHE	26645	64025	FSHI12	26044	62674	FSHI	26644	64024
FSHP	26634	62662	FSH	26705	64121	FSKRA	26632	62660	FSKRB	26022	62646	FSKRC	26012	62634
FSKRD	26002	62622	FSKRE	26001	62621	FSKRF	26000	62620	FSKRK	25999	62617	FSK	26033	62661
FSME	25989	62605	FSMNOP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604	FSMO	25985	62601
GAMM	25984	62600	HE	25983	62577	HH	25982	62576	IALT	25977	62571	IDEL	25976	62570
INDCOU	25975	62567	INDLAS	25965	62555	INDPRI	25954	62542	INDP	25955	62543	INDPS	25953	62541
INDR	25903	62457	INDSTP	25902	62456	INDSTR	25901	62455	INDTYP	25900	62454	IPRINT	23213	55255
JBYCTR	23211	55253	JINPUT	25890	62442	JS	25889	62441	KS	25888	62440	LP2	25886	62436
L	25887	62437	NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433	NS	25884	62434
OGIVEH	25882	62432	OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322	PRAL	25870	62416
PRATIN	25749	62225	PRAT	25809	62321	PRDIRA	25748	62224	PRDS	25688	62130	PRP	25687	62127
PR	25871	62417	PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305	PSI	25225	61211
PSITCU	25165	61115	PS	25685	62125	QW	25164	61114	RESTAR	25162	61112	RETHET	23219	55263
REW	23217	55261	REX	23218	55262	RHO12	25040	60720	RHOCAL	25101	61015	RHOE	25041	60721
RHO	25161	61111	RHOSTG	25039	60717	RN	25038	60716	RNS	25037	60715	R	25163	61113
RSC	24986	60632	RSM	24985	60631	RS	24987	60633	SCHLIN	24984	60630	SCHTIN	24983	60627
SCL	24982	60626	SCT	24922	60532	SHANGL	24862	60436	SIGMAC	24861	60435	SIGMAH	24801	60341
SIGMAU	24741	60245	STADIS	24681	60151	STRLL	23207	55247	STRUL	23206	55246	T12	23209	55251
TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664	THETAT	24499	57663	THPER	24498	57662
TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644	TITLE3	24472	57630	TM	24460	57614
T	24680	60150	TVN2	24400	57520	TVNOP	24398	57516	TVNO	24399	57517	TVO2	24397	57515
U12	24336	57420	UCALC	24335	57417	UE	24275	57323	UINF	24274	57322	ULOLIM	24273	57321
UM1	24212	57224	UM2	24152	57130	UM	24272	57320	U	24396	57514	US	24092	57034
WDBT	24632	56740	XI	23431	55607	XL	23430	55606	XLS	23429	55605	XRN	23379	55523
X	23432	55610	XS	23378	55522	XU12	23377	55521	Y12	23208	55250	YCALC	23316	55424
Y	23376	55570	YTHC	23255	55327	YTH	23256	55330	YTHU	23245	55315	ZIL	23243	55313

Z1R 23242 55312 Z1 23244 55314 Z1S 23232 55300 Z2R 23230 55276 Z2 23231 55277
Z2S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
DIN2	1130	02152	FM1	1129	02151	FMBL	1128	02150	FNE	1127	02147	INO22	1126	02146
INDFOD	1125	02145	I	1124	02144	K	1123	02143	N	1122	02142	RSIME	1121	02141
SCOMP	1120	02140	THETA	1119	02137	TWOPI	1118	02136	UDS	1117	02135	UESTAR	1116	02134
XOD	1115	02133	Z1A	1114	02132	Z1OD	1113	02131						

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
811	17	02102	811A	42	02073	811N	55	02053	812TT	3005	02035			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	1091	02103	2)	1022	01776	3)	1030	02006	6)	1045	02025	C)GO	1102	02116
C)G1	1103	02117	C)G3	1104	02120	C)G5	1105	02121	C)100	1106	02122	C)10[	1107	02123
C)200	1108	02124	C)201	1109	02125	C)202	1110	02126	C)203	1111	02127	C)207	1112	02130
D)11U	615	01147	D)21T	611	01143	D)22A	696	01270	D)31T	610	01142	0)41M	576	01100
D)43D	946	01662	D)61M	575	01077	0)63D	945	01661	E)3	39	00047	E)4	43	00053
E)6	50	00062	E)C	121	00171	E)E	129	00201	E)G	136	00210	E)J	147	00223
E)L	157	00235	E)O	323	00503	E)R	344	00530	E)11	385	00601	E)16	435	00663
E)17	450	00702	E)1B	503	00767	E)1G	549	01045	E)1I	563	01063	E)1M	574	01076
E)1Q	602	01132	E)23	649	01211	E)27	676	01244	E)2F	719	01317	E)2K	761	01371
E)2L	766	01376	E)36	874	01552	E)39	894	01576	E)12A	695	01267	E)120	787	01423
E)13M	1019	01773	E)23M	1019	01773	E)33M	1019	01773	E)535	870	01546	E)63M	1019	01773

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
ATAN	4	00004	CEDGE	9	00011	COS	0	00000	PRTERH	7	00007	SIN	5	00005
SQRT	1	00001	WDOTRT	8	00010	(FIL)	3	00003	(SPH)	2	00002	(STH)	6	00006

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ATAN CEDGE COS PRTERH SIN SQRT WDOTRT (FIL) (SPH) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
2	15	00034	3	16	00041	4	18	00050	5	20	00054	7	21	00056
9	22	00063	10	25	00070	12	27	00074	15	29	00101	16	33	00152
19	36	00172	20	38	00211	25	40	00216	26	41	00224	29	44	00231
30	45	00236	35	48	00250	40	50	00277	50	59	00504	52	60	00506
56	64	00524	58	66	00531	60	68	00537	65	70	00545	70	73	00557
100	75	00563	1003	77	00602	1005	78	00610	1020	84	00642	1021	87	00656
1022	88	00664	1023	90	00703	1025	91	00711	2030	95	00741	2033	99	00770
2035	100	01000	2040	102	01016	2050	104	01041	2052	105	01046	2060	107	01070
2065	108	01073	2070	110	01101	2080	111	01111	2082	112	01115	2090	114	01137
2095	115	01144	2100	117	01150	2103	120	01163	2105	121	01172	2110	123	01176
2115	124	01202	2120	125	01212	2130	126	01220	2140	128	01226	2141	131	01245

2143	132	01254	2145	134	01260	2150	135	01271	2170	136	01275	2180	138	01303
2500	140	01313	2505	141	01320	2510	142	01322	2600	143	01326	3060	150	01372
3109	151	01377	3110	152	01404	3115	153	01416	3120	154	01424	3123	155	01427
3125	157	01435	3130	159	01446	3140	161	01453	3150	162	01456	3155	163	01471
3200	164	01476	3300	166	01501	3400	170	01513	3450	171	01517	3460	173	01525
3470	174	01541	3500	175	01547	3510	176	01553	3520	177	01562	3610	179	01566
3620	182	01577	4000	185	01617	4033	187	01635	4035	188	01643	4040	190	01663
4500	191	01676	4505	192	01702	4510	193	01704	5000	201	01747	5010	203	01755
5555	208	01774												

```
      SUBROUTINE UEDGE(J)
C
      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
     4CSR,DCDP12,DEL,DELTAP,DELTAX,DELXDD,DELXST,DMDP12,DIST,DKDL,
     5DKDT,DN2,DN2DD2,DNC,DD2,DSCRIP,DUDP12,EDENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
     7FEDC,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
      COMMON FIND,FK,FKPSI,FL,FLELIN,FLETIN,FLEWL,FLEWT,
     1FLN2,FLND,FLNDP,FLD2,FM,FMUL,FMUL12,FMUT1M,FMUT1P,FNDSSH,
     2FNDSSL,FSH,FSHE,FSHI,FSH112,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMND,FSMNDP,FSMD,GAMM,HE,
     4HH,IALT,IDEL,INDCDC,INDLAS,INDP,INDPRI,INDPS,INDR,
     5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     6DGIVEH,DGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
      COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVND,TVNDP,TVD2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
     6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
C
      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
     4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
     5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLND(60),
     6FLNDP(60),FLD2(60),FM(10),FMUL(60),FMUT1M(60)
      DIMENSION FMUT1P(60),FSH(60),FSH1(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCDD(10),
     2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)
C
C     UEDGE(1) IS UWALL
C
      J=J
      IF(J-1)30,20,40
   20 UM(1)=0.0
      RETURN
    3 STOP 30
    4 IF(J-3)100,200,50
    5 STOP 50
   10 UM(L)=U(L)-PRP/RHO(L)*DELTAX/U(L)
      RETURN
```

```
200 UM(L+1)=U(L+1)-PRP/RHO(L+1)*DELTAX/U(L+1)
    UM(L+2)=U(L+2)-PRP/RHO(L+2)*DELTAX/U(L+2)
    RETURN
    END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
80	00120	23210	55252

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	AB1T	32552	77450
AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	AB5T	32548	77444	AB6T	32547	77443
AB7T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426	ASR	32533	77425
AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222	B4T	32342	77126
B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	BB1T	32102	76546	BB2T	32101	76545
BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541	BB7T	32096	76540
BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430	BU12	32014	76416
C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041	CM1	30143	72677
CM2	30133	72665	CM	30743	74027	COMEAN	29533	71535	CPE	29531	71533	CP	29532	71534
C	32013	76415	CSR	28930	70402	CS	29530	71532	CSUB	23214	55256	DCDP12	28920	70370
DEL	28910	70356	DELTAP	28909	70355	DELTAX	28908	70354	DELXOD	28907	70353	DELXST	28906	70352
DHDP12	28905	70351	DIST	28904	70350	DKDL	28903	70347	DKDT	28303	67217	DN2002	27702	66066
DN2	27703	66067	DNO	27701	66065	DO2	27700	66064	DSCRIP	27699	66063	DUDP12	27698	66062
EDENS	27697	66061	EPSIC	27636	65764	EPSIH	27635	65763	EPSI	27637	65765	EPSIT	27634	65762
EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757	FB	27630	65756	FC	27629	65755
FEDA	27628	65754	FEDB	27627	65753	FEDC	27626	65752	FH12	27565	65655	FHCALC	27564	65654
FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557	FH	27625	65751	FHS	27383	65367
FINO	27323	65273	FKPSI	27321	65271	FK	27322	65272	FLELIN	27260	65174	FLETIN	27259	65173
FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002	FLNOP	27018	64612	FLNO	27078	64706
FLO2	26958	64516	FL	27261	65175	FM	26898	64422	FMUL12	26828	64314	FMUL	26888	64410
FMUTIN	26827	64313	FMUT1P	26767	64217	FNOSSH	26707	64123	FNDSSL	26706	64122	FNUREW	23215	55257
FNUREX	23216	55260	FSHE	26645	64025	FSHI12	26044	62674	FSHI	26644	64024	FSHP	26034	62662
FSH	26705	64121	FSKRA	26032	62660	FSKRB	26022	62646	FSKRC	26012	62634	FSKRD	26002	62622
FSKRE	26001	62621	FSKRF	26000	62620	FSKRK	25999	62617	FSK	26033	62661	FSME	25989	62605
FSMNOP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604	FSMO	25985	62601	GAMM	25984	62600
HE	25983	62577	HH	25982	62576	IALT	25977	62571	IDEL	25976	62570	INDCOO	25975	62567
INDLAS	25965	62555	INDPRI	25954	62542	INDP	25955	62543	INDPS	25953	62541	INDR	25903	62457
INDSTP	25902	62456	INDSTR	25901	62455	INDTYP	25900	62454	IPRINT	23213	55255	JBYCTR	23211	55253
JINPUT	25890	62442	JS	25889	62441	KS	25888	62440	LP2	25886	62436	L	25887	62437
NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433	NS	25884	62434	OGIVEH	25882	62432
OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322	PRAL	25870	62416	PRATIN	25749	62225
PRAT	25809	62321	PRDIRA	25748	62224	PROS	25688	62130	PRP	25687	62127	PR	25871	62417
PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305	PSI	25225	61211	PSITCU	25165	61115
PS	25685	62125	QW	25164	61114	RESTAR	25162	61112	RETHET	23219	55263	REW	23217	55261
REX	23218	55262	RHO12	25040	60720	RHOCAL	25101	61015	RHOE	25041	60721	RHO	25161	61111
RHOSTG	25039	60717	RN	25038	60716	RNS	25037	60715	R	25163	61113	RSC	24986	60632
RSM	24985	60631	RS	24987	60633	SCHLIN	24984	60630	SCHTIN	24983	60627	SCL	24982	60626
SCT	24922	60532	SHANGL	24862	60436	SIGMAC	24861	60435	SIGMAH	24801	60341	SIGMAU	24741	60245
STADIS	24681	60151	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664	THETAT	24499	57663
THPER	24498	57662	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644	TITLE3	24472	57630
TM	24460	57614	T	24680	60150	TVN2	24400	57520	TVNOP	24398	57516	TVNO	24399	57517
TYO2	24397	57515	U12	24336	57420	UCALC	24335	57417	UE	24275	57323	UINF	24274	57322
ULOLIM	24273	57321	UM1	24212	57224	UM2	24152	57130	UM	24272	57320	U	24396	57514
US	24092	57034	WDOT	24032	56740	XI	23431	55607	XL	23430	55606	XLS	23429	55605
XRB	23379	55523	X	23432	55610	XS	23378	55522	XU12	23377	55521	YCALC	23316	55424
Y	23376	55520	YTHC	23255	55327	YTH	23256	55330	YTHU	23245	55315	Z1L	23243	55313
Z1	23242	55312	Z1	23244	55314	Z1S	23232	55300	Z2R	23230	55276	Z2	23231	55277
Z2S	23229	55264												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
11	78	00116	21	69	00105	31	71	00107	61	72	00110			

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
20	12	00026	30	15	00034	40	16	00036	50	17	00043	100	18	00045
200	21	00061												

```
      SUBROUTINE VISLAT
C
      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
     4CSR,DCDP12,DEL,DELTAP,DELTAX,DELXOD,DELXST,DHDP12,DIST,DKDL,
     5DKDT,DN2,DN2DO2,DNO,DO2,DSCRIP,DUDP12,EDENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
     7FEDC,FH,FH12,FHCALC,FHE,FHH,FHH2,FHS
      COMMON FINO,FK,FKPSI,FL,FLELIN,FLETIN,FLEWL,FLEWT,
     1FLN2,FLNO,FLNOP,FLO2,FM,FMUL,FMUL12,FMUT1M,FMUT1P,FNOSSM,
     2FNOSSL,FSH,FSHE,FSHI,FSHI12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMNO,FSMNOP,FSMO,GAMM,HE,
     4HH,IALT,IDEL,INDCOO,INDLAS,INDP,INDPRI,INDPS,INDR,
     5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     6OGIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
      COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVNO,TVNOP,TVO2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
     6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
     1,FSH12,T12,Y12,STRLL,STRUL,RHOU12,AAU
C
      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
     4EDENS(60),FH(60),FHCALC(60),FHH(60),FHH2(60),FHS(60),
     5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLNO(60),
     6FLNOP(60),FLO2(60),FM(10),FMUL(60),FMUT1M(60)
      DIMENSION FMUT1P(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCOO(10),
     2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)
C
      DO 100 N=1,LP2
  100 FMUL(N)=3.04566E-8*TM(N)**1.5/(110.333+TM(N))
      REUER=RHO(L)*U(L)*RS
      DO 600 N=2,LP2
      IF(N-2)160,160,269
  160 DEL12=SQRTF(DELTAP)
      AAU=(2.0*RHO(2)*U(2)-RHO(3)*U(3))/DEL12/.58579
      BBU=(RHO(3)*U(3)-1.414*RHO(2)*U(2))/DELTAP/.58579
      Y(2)=2.0/BBU/RS*LOGF(1.0+BBU/AAU*DEL12)
      Y12=2.0/BBU/RS*LOGF(1.0+BBU/AAU*SQRTF(.5*DELTAP))
```

```
      RHOU12=AAU*DEL12*.7071+BBU*.5*DELTAP
  180 RURNM=RHO(1)*U12*RS
      RURN1=RHO(2)*U12*RS
      RURN=RHO(2)*U(2)*RS
      RURNP=RHO(3)*U(3)*RS
      Y2K2P=Y(2)+DELTAP*(.375/RURN+.125*RURNP)
      Y2K2M=Y(2)-DELTAP*(.125/RURNM+.375/RURN1)
      P2K2P=PSI(2)+.5*DELTAP
      P2K2M=PSI(2)-.5*DELTAP
      FMUT1M(2)=  RHO12*U12*RS*RHO12 *ABSF(DUDP12)
      GO TO 270
  269 Y(N)=Y(N-1)+.5*DELTAP/RS*(1.0/(RHO(N)*U(N))+1.0/(RHO(N-1)*U(N-1)))
      RURNM=RHO(N-1)*U(N-1)*RS
      RURN=RHO(N)*U(N)*RS
      RURNP=RHO(N+1)*U(N+1)*RS
      Y2K2P=Y(N)+DELTAP*(.375/RURN+.125/RURNP)
      Y2K2M=Y(N)-DELTAP*(.125/RURNM+.375/RURN)
      P2K2P=PSI(N)+.5*DELTAP
      P2K2M=PSI(N)-.5*DELTAP
      FMUT1M(N)=    (RHO(N)+RHO(N-1))*    (RURN+RURNM)*ABSF(U(N)-U(N-1))/
     1DELTAP*.25
  270 FMUT1P(N)=(RHO(N+1)+RHO(N))*(RURNP+RURN)*ABSF(U(N+1)-U(N))/DELTAP*
     1.25
      FLTP=(Y(L)*(.14-.08*(1.0-Y2K2P/Y(L))**2-.06*(1.0-Y2K2P/Y(L))**4))*
     1*2
      FLTM=(Y(L)*(.14-.08*(1.0-Y2K2M/Y(L))**2-.06*(1.0-Y2K2M/Y(L))**4))*
     1*2
      PLTP=(PSI(L)/REUER*(.14-.08*(1.0-P2K2P/PSI(L))**2-.06*(1.0-P2K2P/P
     1SI(L))**4))**2
      PLTM=(PSI(L)/REUER*(.14-.08*(1.0-P2K2M/PSI(L))**2-.06*(1.0-P2K2M/P
     1SI(L))**4))**2
      FMUT2P=.25*(RHO(N+1)+RHO(N))*(FKPSI(N+1)+FKPSI(N))*Y(L)*U(L)
      FMUT2M=.25*(RHO(N)+RHO(N-1))*(FKPSI(N)+FKPSI(N-1))*Y(L)*U(L)
      FMUT6P=FMUT2P/Y(L)*PSI(L)/REUER
      FMUT6M=FMUT2M/Y(L)*PSI(L)/REUER
      FMUT1P(N)=B1T(N+1)*(Y2K2P*FK)**2*FMUT1P(N)+B2T(N+1)*FMUT2P+B3T(N+1
     1)*.5*(FMUL(N)+FMUL(N+1))+B4T(N+1)*FLTP*FMUT1P(N)
     2+B5T(N+1)*(P2K2P*FK/REUER)**2*FMUT1P(N)+B6T(N+1)*FMUT6P+B7T(N+1)*
     3PLTP*FMUT1P(N)
  600 FMUT1M(N)=B1T(N)*(Y2K2M*FK)**2*FMUT1M(N)+B2T(N)*FMUT2M+B3T(N)*.5*(
     1FMUL(N)+FMUL(N-1))+B4T(N)*FLTM*FMUT1M(N)
     2+B5T(N)*(P2K2M*FK/REUER)**2*FMUT1M(N)+B6T(N)*FMUT6M+B7T(N)*PLTM*
     3FMUT1M(N)
      IF(SENSE SWITCH 2)650,700
  650 WRITE OUTPUT TAPE 6,655,AU12,XU12
  655 FORMAT(1GX5HAU12=1PE13.5,5HXU12=1PE13.5)
  700 RETURN
      END(1,1,C,0,0,0,0,1,0,0,0,0,0,0,0)
```

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
633	01171	23203	55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	AAU	23204	55244
AB1T	32552	77450	AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	AB5T	32548	77444
AB6T	32547	77443	ABTT	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426
ASR	32533	77425	AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222
B4T	32342	77126	B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	BB1T	32102	76546
BB2T	32101	76545	BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541
BB7T	32096	76540	BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430
BU12	32014	76416	C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041
CM1	30143	72677	CM2	30133	72665	CM	30743	74027	CONEAN	29533	71535	CPE	29531	71533
CP	29532	71534	C	32013	76415	CSR	28930	70402	CS	29530	71532	CSUB	23214	55256
DCDP12	28920	70370	DEL	28910	70356	DELTAP	28909	70355	DELTAX	28908	70354	DELXOD	28907	70353
DELXST	28906	70352	DHDP12	28905	70351	DIST	28904	70350	DKDL	28903	70347	DKDT	28303	67217
DN2DO2	27702	66066	DN2	27703	66067	DNO	27701	66065	DO2	27700	66064	DSCRIP	27699	66063
DUDP12	27698	66062	EDENS	27697	66061	EPSIC	27636	65764	EPSIH	27635	65763	EPSI	27637	65765
EPSIT	27634	65762	EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757	FB	27630	65756
FC	27629	65755	FEDA	27628	65754	FEDB	27627	65753	FEDC	27626	65752	FH12	27565	65655
FHCALC	27564	65654	FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557	FH	27625	65751
FHS	27383	65367	FINO	27323	65273	FKPSI	27321	65271	FK	27322	65272	FLELIN	27260	65174
FLETIN	27259	65173	FLEWL	27258	65172	FLENT	27198	65076	FLN2	27138	65002	FLNOP	27018	64612
FLNO	27078	64706	FLO2	26958	64516	FL	27261	65175	FM	26898	64422	FMUL12	26828	64314
FMUL	26888	64410	FMUTIM	26827	64313	FMUTIP	26767	64217	FNDSSH	26707	64123	FNDSSL	26706	64122
FNUREW	23215	55257	FNUREX	23216	55260	FSH12	23210	55252	FSHE	26645	64025	FSHI12	26044	62674
FSHI	26644	64024	FSHP	26034	62662	FSH	26705	64121	FSKRA	26032	62660	FSKRB	26022	62648
FSKRC	26012	62634	FSKRD	26002	62622	FSKRE	26001	62621	FSKRF	26000	62620	FSKRK	25999	62617
FSK	26033	62661	FSME	25989	62605	FSMNOP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604
FSMO	25985	62601	GAMM	25984	62600	HE	25983	62577	HH	25982	62576	IALT	25977	62571
IDEL	25976	62570	INDCOO	25975	62567	INDLAS	25965	62555	INDPRI	25954	62542	INDP	25955	62543
INDPS	25953	62541	INDR	25903	62457	INDSTP	25902	62456	INDSTR	25901	62455	INDTYP	25900	62454
IPRINT	23213	55255	JBYCTR	23211	55253	JIMPUT	25890	62442	JS	25889	62441	KS	25888	62440
LP2	25886	62436	L	25887	62437	NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433
NS	25884	62434	OGIVEH	25882	62432	OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322
PRAL	25870	62416	PRATIN	25749	62225	PRAT	25809	62321	PRDIRA	25748	62224	PRDS	25688	62130
PRP	25687	62127	PR	25871	62417	PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305
PSI	25225	61211	PSITCU	25165	61115	PS	25685	62125	QW	25164	61114	RESTAR	25162	61112
RETHET	23219	55263	REW	23217	55261	REX	23218	55262	RHO12	25040	60720	RHOCAL	25101	61015
RHOE	25041	60721	RHO	25161	61111	RHOSTG	25039	60717	RHOU12	23205	55245	RN	25038	60716
RNS	25037	60715	R	25163	61113	RSC	24986	60632	RSM	24985	60631	RS	24987	60633
SCHLIN	24984	60630	SCHTIN	24983	60627	SCL	24982	60626	SCT	24922	60532	SHANGL	24862	60436
SIGMAC	24861	60435	SIGMAH	24801	60341	SIGMAU	24741	60245	STADIS	24681	60151	STRLL	23207	55247
STRUL	23206	55246	T12	23209	55251	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664
THETAT	24499	57663	THPER	24498	57662	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644
TITLE3	24472	57630	TM	24460	57614	T	24680	60150	TVN2	24400	57520	TVNOP	24398	57516
TVNO	24399	57517	TVO2	24397	57515	U12	24336	57420	UCALC	24335	57417	UE	24275	57323
UINF	24274	57322	ULOLIM	24273	57321	UM1	24212	57224	UM2	24152	57130	UM	24272	57320
U	24396	57514	US	24092	57034	WDOT	24032	56740	XI	23431	55607	XL	23430	55606
XLS	23429	55605	XRP	23379	55523	X	23432	55610	XS	23378	55522	XU12	23377	55521
Y12	23208	55250	YCAL	23316	55424	Y	23376	55550	YTHC	23255	55327	YTH	23256	55330

YTHU	23245	55315	Z1L	23243	55313	Z1R	23242	55312	Z1	23244	55314	Z1S	23232	55300
Z2R	23230	55276	Z2	23231	55277	Z2S	23220	55264						

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
BBU	632	01170	DEL12	631	01167	FLTM	630	01166	FLTP	629	01165	FMUT2M	628	01164
FMUT2P	627	01163	FMUT6M	626	01162	FMUT6P	625	01161	N	624	01160	P2K2M	623	01157
P2K2P	622	01156	PLTM	621	01155	PLTP	620	01154	REUER	619	01153	RURN1	618	01152
RURNM	617	01151	RURNP	616	01150	RURN	615	01147	Y2K2M	614	01146	Y2K2P	613	01145

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)KF	655	01131												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	602	01132	2)	571	01073	3)	575	01077	6)	590	01116	C)GI	612	01144
E)8	554	01052												

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP(3	0	00000	LOG	2	00002	SQRT	1	00001	(FIL)	4	00004	(STH)	3	00003

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP(3 LOG SQRT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
100	12	00022	160	16	00055	180	22	00157	269	32	00261	270	41	00406
600	51	00761	650	53	01053	700	55	01067						

```
C
      SUBROUTINE WDDTRT(NSTART,NEND)

      SUBROUTINE WDDTRT(NSTART,NEND)
C
      COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
     1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
     2B4T,B5T,B6T,B7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BC12,BH12,
     3BLOCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CDNEAN,CP,CPE,CS,
     4CSR,DCDP12,DEL,DELTAP,DELTAX,DELXDD,DELXST,DHDP12,DIST,DKDL,
     5DKDT,DN2,DN2DD2,DNC,DD2,DSCRIP,DUDP12,EDENS,EPSI,
     6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
     7FEDC,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
      COMMON FINO,FK,FKPSI,FL,FLELIN,FLETIN,FLEWL,FLEWT,
     1FLN2,FLND,FLNDP,FLD2,FM,FMUL,FMUL12,FMUT1M,FMUT1P,FNDSSH,
     2FNDSSL,FSH,FSHE,FSHI,FSHI12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
     3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMND,FSMNDP,FSMD,GAMM,HE,
     4HH,IALT,IDEL,INDCDC,INDLAS,INDP,INOPRI,INDPS,INDR,
     5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
     6DGIVEH,DGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PROIRA
      COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RHO,
     1RHOCAL,RHOE,RHO12,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
     2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
     3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
     4TITLE1,TITLE2,TITLE3,TM,TVN2,
     5TVNO,TVNDP,TVD2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
     6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
     7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
      COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
     1,FSH12,T12,Y12,STRLL,STRUL,RHOU12,AAU,EHP,FSK15,
     2FSMD15,FSMN15,FSME5
C
      DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60)
     1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
     2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
     3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
     4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
     5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLND(60),
     6FLNDP(60),FLD2(60),FM(10),FMUL(60),FMUT1M(60)
      DIMENSION FMUT1P(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
     1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCOD(10),
     2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
     3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
     4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
     5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
     6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
      DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
     1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
     2Z2R(10)
C
   10 NSTART=NSTART
      NEND=NEND
      DO 300 N=NSTART,NEND
      ETT228=5.D+3.0*EXPF(-228.0/T(N))+EXPF(-327.0/T(N))
      ET178=1.0+EXPF(-178.D/T(N))
      ET2274=1.D-EXPF(-2274.C/T(N))
      ET2740=1.0-EXPF(-2740.0/T(N))
      ET3395=1.D-EXPF(-3395.0/T(N))
      ET1130=3.D+2.D*EXPF(-11300.D/T(N))
```

```
C
      RHOOO=FM(2)*11.584906/T(N)*ET2274*ETT228**2/ET1130*FSMO15
     1*FSK15*3.87871E-11*T(N)**1.5/EHP
      RHOON=FM(4)*257.8804/T(N)*ET3395*FSMN15*FSK15
     1*3.87871E-11*T(N)**1.5/EHP
      RHODNO=FM(2)*77.267586*(FM(4)/FM(5))**2.5/T(N)*ET2740*ETT2
     128/ET178*FSMO15*FSK15*3.87871E-11*T(N)**1.5/EHP
      RHODE=FM(7)*13.346219*ET2740/ET3395/ET178*FSME5
     1*FSK15*3.87871E-11*T(N)**1.5/EHP*FSME
      SIGMA=(FM(1)*FM(4)/FM(5)/FM(2))**2.5*.1790*ET2740/ET2274*ET1130/E
     1TT228/ET178
      GAMMA=(FM(5)*FM(4)/FM(3)/FM(2))**2.5*18.88*ET3395/ET2740*ET178/ETT
     1228
      FKBAR=( FM(6)*FM(7) /FM(4)/FM(2))**2.5*T(N)/5.789/ET3395/ETT228
      TT2=1.0/SQRTF(TM(N))
      T32=TT2*TT2*TT2
      FSKRA(1)=2.2E-7*T32
      FSKRA(2)=6.2E-7*T32
      FSKRA(3)=1.7E-11*TT2
      FSKRA(4)=8.3E-12*TT2
      FSKRA(5)=FSKRA(4)
      FSKRA(6)=FSKRA(4)
      FSKRA(7)=FSKRA(4)
      FSKRB(1)=3.0E-11*TT2
      FSKRB(2)=FSKRB(1)
      FSKRB(3)=7.6E-11*TT2
      FSKRC(4)=6.5E-6*T32
      FSKRB(5)=FSKRB(1)
      FSKRB(6)=FSKRB(1)
      FSKRB(7)=FSKRB(1)
      FSKRC(1)=2.8E-7*T32
      FSKRC(2)=FSKRC(1)
      FSKRC(3)=FSKRC(1)
      FSKRC(4)=FSKRC(1)
      FSKRC(5)=5.5E-6*T32
      FSKRC(6)=FSKRC(1)
      FSKRC(7)=FSKRC(1)
      FSKRO=2.2E-14*TM(N)*EXPF(-3560./TM(N))
      FSKRF=3.0E-3*T32
      FSKRK(1)=FSKRA(1)
      FSKRK(2)=FSKRK(1)
      FSKRK(3)=FSKRK(1)
      FSKRK(4)=FSKRK(1)
      FSKRK(5)=FSKRK(1)
      FSKRK(6)=FSKRK(1)
      FSKRK(7)=FSKRK(1)
      FSKT=FSK*T(N)*.846389E19
      EMDO2=EXPF(-DO2/FSKT)
      EMON2=EXPF(-DN2/FSKT)
      EMONO=EXPF(-ONO/FSKT)
      EMINO=EXPF(-FINO/FSKT)
      SUMCM=0.0
      SUMCMA=0.0
      SUMCMB=0.0
      SUMCMC=0.0
      SUMCMK=0.0
      DO 150 I=1,NS
```

```
      SUBROUTINE WDOTRT(NSTART,NEND)

C
      SUMCM=SUMCM+C(N,I)/FM(I)
      SUMCMA=SUMCMA+C(N,I)/FM(I)*FSKRA(I)
      SUMCMB=SUMCMB+C(N,I)/FM(I)*FSKRB(I)
      SUMCMC=SUMCMC+C(N,I)/FM(I)*FSKRC(I)
  150 SUMCMK=SUMCMK+C(N,I)/FM(I)*FSKRK(I)
      A=2.0*FL/FM(2)*SUMCMA*RHO(N)*(RHOOO*C(N,1)*1.94008E25*EMOO2-RHO(N)
     1*1.94008E25*C(N,2)**2)*4.9778
      B=2.0*FL/FM(4)*SUMCMB*RHO(N)*(RHOON*C(N,3)*1.94008E25*EMON2-RHO(N)
     1*1.94008E25*C(N,4)**2)*4.9778
      G=FL*FM(5)/FM(4)/FM(2)*SUMCMC*RHO(N)*(RHOONO*C(N,5)*1.94008E25*EMO
     1NO-RHO(N)*1.94008E25*C(N,4)*C(N,2))*4.9778
      O=FL*FM(5)/FM(4)/FM(1)*FSKRO*RHO(N)*(SIGMA*C(N,5)*C(N,2)*1.94008E2
     15*EMONO/EMOO2-C(N,1)*1.94008E25*C(N,4))*1.6018E-2
      E=FL*FSKRE/FM(4)*RHO(N)*(GAMMA*C(N,3)*1.94008E25*C(N,2)*EMON2/EMON
     1O-C(N,5)*1.94008E25*C(N,4))*1.6018E-2
      F=FL*FSKRF/FM(7)*RHO(N)*(FKBAR*C(N,2)*1.94008E25*C(N,4)*EMINO/EMON
     1O-C(N,6)*1.94008E25*C(N,7))*1.6018E-2
      TK=FL/FM(7)*SUMCMK*RHO(N)*(RHOOE*C(N,5)*1.94008E25*EMINO-RHO(N)*C(
     1N,6)*1.94008E25*C(N,7))*4.9778
      WDOT(N,2)=(A+FM(2)/FM(5)*(G-O-E)-FM(2)/FM(6)*F)*RHO(N)/FL
      WDOT(N,4)=(B+FM(4)/FM(5)*(G+O+E)-FM(4)/FM(6)*F)*RHO(N)/FL
      WDOT(N,1)=(-A+FM(1)/FM(5)*O)*RHO(N)/FL
      WDOT(N,3)=-(B+FM(3)/FM(5)*E)*RHO(N)/FL
      WDOT(N,5)=(-G-O+E-TK)*RHO(N)/FL
      WDOT(N,6)=(F+TK)*RHO(N)/FL
      IF(SENSE SWITCH 3)250,300
  250 WRITE OUTPUT TAPE 6,255,A,B,G,O,E,F,TK,SUMCM,SUMCMA,SUMCMB,SUMCMC,
     1SUMCMK,EMOO2,EMON2,EMONO,EMINO,FSKRA(1),FSKRB(1),FSKRC(1),FSKRE,FS
     2KRF,FSKRK(1),RHOOO,RHOON,RHOONO,RHOOE,SIGMA,GAMMA,FKBAR,ETA,ET228
     3,ET178,ET2274,ET2740,ET3395,ET1130,T(N),TM(N),TT2,T32,FSKT
  255 FORMAT(1H 7E10.3)
  300 WDOT(N,7)=(F+TK)*RHO(N)/FL*FM(7)/FM(6)
      RETURN
      END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

C

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
858	01532	23198	55236

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	A8U	23204	55244
AB1T	32552	77450	AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	A85T	32548	77444
A86T	32547	77443	A87T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426
ASR	32533	77425	AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	B3T	32402	77222
B4T	32342	77126	B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	BB1T	32102	76546
BB2T	32101	76545	BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541
BB7T	32096	76540	BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430
BU12	32014	76416	C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041
CM1	30143	72677	CM2	30133	72665	CM	30743	74027	CONEAN	29533	71535	CPE	29531	71533
CP	29532	71534	C	32013	76415	CSR	28930	70402	CS	29530	71532	CSUB	23214	55256
DCDP12	28920	70370	DEL	28910	70356	DELTAP	28909	70355	DELTAX	28908	70354	DELXDD	28907	70353
DELXST	28906	70352	DHDP12	28905	70351	DIST	28904	70350	DKDL	28903	70347	DKDT	28303	67217
DN2D02	27702	66066	DN2	27703	66067	DND	27701	66065	DQ2	27700	66064	DSCRIP	27699	66063
DUDP12	27698	66062	EDENS	27697	66061	EHP	23203	55243	EPSIC	27636	65764	EPSIH	27635	65763
EPSI	27637	65765	EPSIT	27634	65762	EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757
FB	27630	65756	FC	27629	65755	FEDA	27628	65754	FEDB	27627	65753	FEDC	27626	65752
FH12	27565	65655	FHCALC	27564	65654	FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557
FH	27625	65751	FHS	27383	65367	FIND	27323	65273	FKPSI	27321	65271	FK	27322	65272
FLELIN	27260	65174	FLETIN	27259	65173	FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002
FLNOP	27018	64612	FLNO	27078	64706	FLD2	26958	64516	FL	27261	65175	FM	26898	64422
FMUL12	26828	64314	FMUL	26888	64410	FMUT1M	26827	64313	FMUT1P	26767	64217	FNDSSH	26707	64123
FNDSSL	26706	64122	FNUREW	23215	55257	FNUREX	23216	55260	FSH12	23210	55252	FSHE	26645	64025
FSHI12	26044	62674	FSHI	26644	64024	FSHP	26034	62662	FSH	26705	64121	FSK15	23202	55242
FSKRA	26032	62660	FSKR8	26022	62646	FSKRC	26012	62634	FSKRD	26002	62622	FSKRE	26001	62621
FSKRF	26000	62620	FSKRK	25999	62617	FSK	26033	62661	FSME5	23199	55237	FSME	25989	62605
FSMN15	23200	55240	FSMNCP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604	FSMD15	23201	55241
FSMO	25985	62601	GAMM	25984	62600	HE	25983	62577	HH	25982	62576	IALT	25977	62571
IDEL	25976	62570	INDCCD	25975	62567	INDLAS	25965	62555	INDPRI	25954	62542	INDP	25955	62543
INDPS	25953	62541	INDR	25903	62457	INDSTP	25902	62456	INDSTR	25901	62455	INDTYP	25900	62454
IPRINT	23213	55255	JBYCTR	23211	55253	JINPUT	25890	62442	JS	25889	62441	KS	25888	62440
LP2	25886	62436	L	25887	62437	NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433
NS	25884	62434	CGIVEH	25882	62432	OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322
PRAL	25870	62416	PRATIN	25749	62225	PRAT	25809	62321	PRDIRA	25748	62224	PRDS	25688	62130
PRP	25687	62127	PR	25871	62417	PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305
PSI	25225	61211	PSITCU	25165	61115	PS	25685	62125	QW	25164	61114	RESTAR	25162	61112
RETHET	23219	55263	REW	23217	55261	REX	23218	55262	RHO12	25040	60720	RHOCAL	25101	61015
RHOE	25041	60721	RHO	25161	61111	RHOSTG	25039	60717	RHOU12	23205	55245	RN	25038	60716
RNS	25037	60715	R	25163	61113	RSC	24986	60632	RSM	24985	60631	RS	24987	60633
SCHLIN	24984	60630	SCHTIN	24983	60627	SCL	24982	60626	SCT	24922	60532	SHANGL	24862	60436
SIGMAC	24861	60435	SIGMAH	24801	60341	SIGMAU	24741	60245	STADIS	24681	60151	STRLL	23207	55247
STRUL	23206	55246	T12	23209	55251	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664
THETAT	24499	57663	THPER	24498	57662	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644
TITLE3	24472	57630	TM	24460	57614	T	24680	60150	TVN2	24400	57520	TVNDP	24398	57516
TVNO	24399	57517	TVC2	24397	57515	U12	24336	57420	UCALC	24335	57417	UE	24275	57323
UINF	24274	57322	ULOLIM	24273	57321	UM1	24212	57224	UM2	24152	57130	UM	24272	57320
U	24396	57514	US	24092	57034	WDOT	24032	56740	XI	23431	55607	XL	23430	55606
XLS	23429	55605	XRN	23379	55523	X	23432	55610	XS	23378	55522	XU12	23377	55521

Y12	23208	55250	YCALC	23316	55424	Y	23376	55520
YTHC	23255	55327	YTH	23256	55330	YTHU	23245	55315
Z1L	23243	55313	Z1R	23242	55312	Z1	23244	55314
Z1S	23232	55300	Z2R	23230	55276	Z2	23231	55277
Z2S	23220	55264						

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	857	01531	B	856	01530	D	855	01527	EMON2	854	01526	EMONO	853	01525
EM002	852	01524	EMINO	851	01523	E	850	01522	ET1130	849	01521	ET178	848	01520
ET2274	847	01517	ET2740	846	01516	ET3395	845	01515	ETT228	844	01514	FKBAR	843	01513
F	842	01512	FSKT	841	01511	GAMMA	840	01510	G	839	01507	RHODE	838	01508
RHOONO	837	01505	RHODN	836	01504	RHODO	835	01503	SIGMA	834	01502	SUMCMA	833	01501
SUMCMB	832	01500	SUMCMC	831	01477	SUMCMK	830	01476	SUMCM	829	01475	T32	828	01474
TK	827	01473	TT2	826	01472									

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)7V	255	01463												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	820	01464	2)	770	01402	3)	774	01406	6)	812	01454	C)GO	825	01471

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
EXP	0	00000	EXP(3	1	00001	SQRT	2	00002	(FIL)	4	00004	(STH)	3	00003

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP EXP(3 SQRT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
10	11	00030	150	74	00645	250	89	01230	300	91	01362			

APPENDIX III

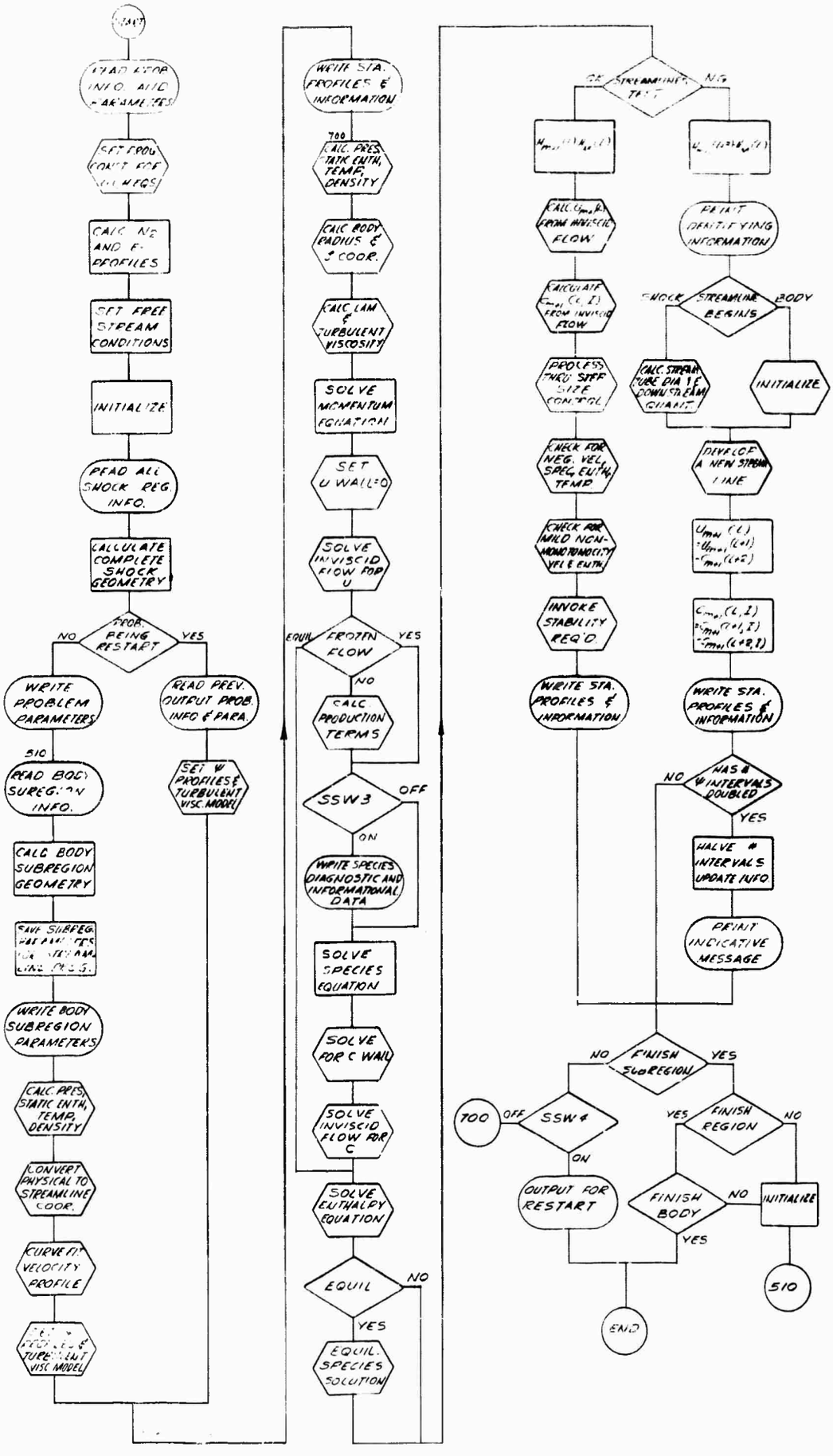
FLOW DIAGRAM

APPENDIX III

FLOW DIAGRAM

CHEMICALLY REACTING [illegible] LAYER

OVERALL PROGRAM LOGIC



APPENDIX 4

SAMPLE INPUT

TITLE CARD
FIRING RANGE BLUNTED CONE

TITLE CARD
NON UNITY FLOW PARAMETERS

TITLE CARD
LAMINAR CHEMISTRY RUN

LP2	NS	NPSI	INDSTR	FNDSSL	FNDSSH	IALT
20	7	1	1	.5E-2	.75E-1	150

AIL	AIT	A2	A3L	A3T	A4L	A4T
1.0E0	0.0E0	1.0E0	1.0E0	0.0E0	1.0E0	0.0E0

A5L	A5T	C(1,1)	C(2,1)	C(3,1)	C(4,1)	C(5,1)
1.0E0	0.0E0	.22741E0	.22170E0	.21183E0	.17982E0	.14297E0

C(6,1)	C(7,1)	C(8,1)	C(9,1)	C(10,1)	C(11,1)	C(12,1)
.11150E0	.85382E-1	.62616E-1	.43567E-1	.29410E-1	.20097E-1	.16908E-1

C(13,1)	C(14,1)	C(15,1)	C(16,1)	C(17,1)	C(18,1)	C(19,1)
.14904E-1	.14469E-1	.14469E-1	.14469E-1	.14469E-1	.14469E-1	.14469E-1

C(20,1)	C(1,2)	C(2,2)	C(3,2)	C(4,2)	C(5,2)	C(6,2)
.14469E-1	.67227E-3	.33476E-2	.10007E-1	.36819E-1	.71043E-1	.10170E0

C(7,2)	C(8,2)	C(9,2)	C(10,2)	C(11,2)	C(12,2)	C(13,2)
.12798E0	.15152E0	.17185E0	.18753E0	.19831E0	.20215E0	.20462E0

C(14,2)	C(15,2)	C(16,2)	C(17,2)	C(18,2)	C(19,2)	C(20,2)
.20516E0	.20516E0	.20516E0	.20516E0	.20516E0	.20516E0	.20516E0

C(1,4)	C(2,4)	C(3,4)	C(4,4)	C(5,4)	C(6,4)	C(7,4)
.14702E-8	.30977E-7	.25366E-6	.34105E-5	.14424E-4	.35360E-4	.69228E-4

C(8,4)	C(9,4)	C(10,4)	C(11,4)	C(12,4)	C(13,4)	C(14,4)
.12614E-3	.22343E-3	.37977E-3	.60274E-3	.73494E-3	.84654E-3	.87483E-3

C(15,4)	C(16,4)	C(17,4)	C(18,4)	C(19,4)	C(20,4)	C(1,5)
.87483E-3	.87483E-3	.87483E-3	.87483E-3	.87483E-3	.87483E-3	.73356E-2

C(2,5)	C(3,5)	C(4,5)	C(5,5)	C(6,5)	C(7,5)	C(8,5)
.13023E-1	.19050E-1	.28800E-1	.33728E-1	.35239E-1	.34955E-1	.33489E-1

C(9,5)	C(10,5)	C(11,5)	C(12,5)	C(13,5)	C(14,5)	C(15,5)
.31103E-1	.28245E-1	.25478E-1	.24262E-1	.23396E-1	.23195E-1	.23195E-1

C(16,5)	C(17,5)	C(18,5)	C(19,5)	C(20,5)	C(1,6)	C(2,6)
.23195E-1	.23195E-1	.23195E-1	.23195E-1	.23195E-1	.36175E-11	.93313E-10

C(3,6)	C(4,6)	C(5,6)	C(6,6)	C(7,6)	C(8,6)	C(9,6)
.87854E-9	.13790E-7	.61681E-7	.15267E-6	.29524E-6	.52305E-6	.88771E-6

C(10,6)	C(11,6)	C(12,6)	C(13,6)	C(14,6)	C(15,6)	C(16,6)
.14312E-5	.21502E-5	.25554E-5	.28882E-5	.29714E-5	.29714E-5	.29714E-5

C(17,6)	C(18,6)	C(19,6)	C(20,6)
.29714E-5	.29714E-5	.29714E-5	.29714E-5

RESTAR	DELTAX	EPSI	EPSIU	EPSIC	EPSIH	EPSIT
1.0E0	1.0E-9	1.0E0	0.5E-3	0.0E0	1.0E-4	1.0E-2

H(1)	H(2)	H(3)	H(4)	H(5)	H(6)	H(7)
.26496E8	.31276E8	.36058E8	.45620E8	.55182E8	.64744E8	.74306E8

H(8)	H(9)	H(10)	H(11)	H(12)	H(13)	H(14)
.83868E8	.93428E8	1.02985E8	1.12551E8	1.17333E8	1.21160E8	1.22112E8

H(15)	H(16)	H(17)	H(18)	H(19)	H(20)	FK
1.22113E8	1.22114E8	1.22115E8	1.22116E8	1.22116E8	1.22116E8	.4E0

CPE	FL	FSHE	GAMM	PE	RHOE	RHOSTG
.432E0	1.0E0	1.20096E2	1.4E0	3.0597E0	3.5642E-6	4.1379E-5

CE(1)	CE(2)	CE(3)	CE(4)	CE(5)	CE(6)	CE(7)
.232E0	0.0E0	.768E0	0.0E0	0.0E0	0.0E0	0.0E0

RN	UINF	ULOLIM	XS	Z1S	Z2S	Z1L
.05E0	15.2E3	100.E0	.0519E0	.02806E0	.041305E0	1.5E0

U(1)	U(2)	U(3)	U(4)	U(5)	U(6)	U(7)
0.0E0	.42518E3	.85037E3	.17007E4	.25511E4	.34014E4	.42518E4

U(8)	U(9)	U(10)	U(11)	U(12)	U(13)	U(14)
.51022E4	.59525E4	.68029E4	.76533E4	.80785E4	.84186E4	.85037E4

U(15)	U(16)	U(17)	U(18)	U(19)	U(20)
.85037E4	.85037E4	.85037E4	.85037E4	.85037E4	.85037E4

FA	FB	FC	TESTRA	AB1T	AB2T	AB3T
0.4E0	0.0E0	0.0E0	2.0E-1	0.0E0	0.0E0	0.0E0

AB4T	AB5T	AB6T	AB7T	BB1T	BB2T	BB3T
0.0E0	0.0E0	0.0E0	0.0E0	0.0E0	0.0E0	0.0E0

BB4T	BB5T	BB6T	BB7T	FLELIN	FLETIN	PRALIN
0.0E0	0.0E0	0.0E0	0.0E0	1.4E0	1.4E0	.7E0

PRATIN	SCHLIN	SCHTIN	Y(1)	Y(2)	Y(3)	Y(4)
.7E0	.5E0	.5E0	0.0E0	.52716E-4	.11128E-3	.24304E-3

Y(5)	Y(6)	Y(7)	Y(8)	Y(9)	Y(10)	Y(11)
.39216E-3	.55812E-3	.74335E-3	.95388E-3	.12015E-2	.15123E-2	.19643E-2

Y(12)	Y(13)	Y(14)	Y(15)	Y(16)	Y(17)	Y(18)
.23168E-2	.24369E-2	.25270E-2	.26171E-2	.27072E-2	.27973E-2	.28874E-2

Y(19)	Y(20)
.29775E-2	.30673E-2

INOPRI	NSR	JINPUT	THPER
5	4	20	.99E0

ASR(1)	BSR(1)	CSR(1)	Z1R(1)	Z2R(1)	IND TYP	IND COO	IND LAS
0.0E0	5.3775E0	0.0E0	1.036E-3	1.3880E-2	6	1	0

ASR(2)	BSR(2)	CSR(2)	Z1R(2)	Z2R(2)	IND TYP	IND COO	IND LAS
.60962E-3	13.067	.81680E-2	.042663E0	.064899E0	6	1	0

ASR(3)	BSR(3)	CSR(3)	Z1R(3)	Z2R(3)	IND TYP	IND COO	IND LAS
9.6118E-3	1.6625E1	.020312E0	.390380E0	.168759E0	6	1	0

ASR(4)	BSR(4)	CSR(4)	Z1R(4)	Z2R(4)	IND TYP	IND COO	IND LAS
.2026F0	.0896068E0	0E0	1.5E0	1.50E0	2	1	1

INDP	INDR	INDLR	INDLSR	INDS5	INDS6	INDS7
2	1	0	0	0	0	0

OGIVEH	OGIVEK	P(1)	P(2)	P(3)	P(4)	P(5)
.0534E0	0.0E0	0.0E0	593.330E0	-410.15E0	0.0E0	0.0E0

P(6)	P(7)	P(8)	CC(1,1)	CC(2,1)	CC(3,1)	CC(4,1)
0.0F0	0.0E0	0.0E0	.22741E0	0.0E0	0.0E0	0.0E0

CC(5,1)	CC(1,2)	CC(2,2)	CC(3,2)	CC(4,2)	CC(5,2)	CC(1,3)
0.0E0	.67227E-3	0.0E0	0.0E0	0.0E0	0.0E0	.76457E0

CC(2,3)	CC(3,3)	CC(4,3)	CC(5,3)	CC(1,4)	CC(2,4)	CC(3,4)
0.0E0	0.0E0	0.0E0	0.0E0	.14702E-8	0.0E0	0.0E0

CC(4,4)	CC(5,4)	CC(1,5)	CC(2,5)	CC(3,5)	CC(4,5)	CC(5,5)
0.0E0	0.0E0	.73356E-2	0.0E0	0.0E0	0.0E0	0.0E0

CC(1,6)	CC(2,6)	CC(3,6)	CC(4,6)	CC(5,6)	HH1	HH2
36175E-11	0.0E0	0.0E0	0.0E0	0.0E0	.26496E8	0.0E0

HH3	HH4	HH5	RN	XL	CONEAN
0.0F0	0.0E0	0.0E0	.05E0	.06175E0	0.0E0

INDP	INDR	INDLR	INDLSR	INDS5	INDS6	INDS7
2	1	0	1	0	0	0

OGIVEH	OGIVEK	P(1)	P(2)	P(3)	P(4)	P(5)
.0534E0	0.0E0	0.0E0	213.56E0	-102.64E0	0.0E0	0.0E0

P(6)	P(7)	P(8)	CC(1,1)	CC(2,1)	CC(3,1)	CC(4,1)
0.0F0	0.0E0	0.0E0	.22741E0	0.0E0	0.0E0	0.0E0

CC(5,1)	CC(1,2)	CC(2,2)	CC(3,2)	CC(4,2)	CC(5,2)	CC(1,3)
0.0E0	.67227E-3	0.0E0	0.0E0	0.0E0	0.0E0	.76457E0

CC(2,3)	CC(3,3)	CC(4,3)	CC(5,3)	CC(1,4)	CC(2,4)	CC(3,4)
0.0F0	0.0E0	0.0E0	0.0E0	.14702E-8	0.0E0	0.0E0

CC(4,4)	CC(5,4)	CC(1,5)	CC(2,5)	CC(3,5)	CC(4,5)	CC(5,5)
0.0E0	0.0E0	.73356E-2	0.0E0	0.0E0	0.0E0	0.0E0

CC(1,6)	CC(2,6)	CC(3,6)	CC(4,6)	CC(5,6)	HH1	HH2
36175E-11	0.0E0	0.0E0	0.0E0	0.0E0	.26496E8	0.0E0

HH3	HH4	HH5	RN	XL	CONEAN
0.0E0	0.0E0	0.0E0	.05E0	.0717E0	0E0

INDP	INDR	INDLR	INDLSR	INDS5	INDS6	INDS7
2	2	0	0	0	0	0

OGIVEH	OGIVEK	P(1)	P(2)	P(3)	P(4)	P(5)
0.0E0	0.0E0	0.0E0	213.56E0	-102.64E0	0E0	0E0

P(6)	P(7)	P(8)	CC(1,1)	CC(2,1)	CC(3,1)	CC(4,1)
0E0	0E0	0E0	.22741E0	0.0E0	0.0E0	0.0E0

CC(5,1)	CC(1,2)	CC(2,2)	CC(3,2)	CC(4,2)	CC(5,2)	CC(1,3)
0.0E0	.67227E-3	0.0E0	0.0E0	0.0E0	0.0E0	.76457E0

CC(2,3)	CC(3,3)	CC(4,3)	CC(5,3)	CC(1,4)	CC(2,4)	CC(3,4)
0.0E0	0.0E0	0.0E0	0.0E0	.14702E-8	0.0E0	0.0E0

CC(4,4)	CC(5,4)	CC(1,5)	CC(2,5)	CC(3,5)	CC(4,5)	CC(5,5)
0.0E0	0.0E0	.73356E-2	0.0E0	0.0E0	0.0E0	0.0E0

CC(1,6)	CC(2,6)	CC(3,6)	CC(4,6)	CC(5,6)	HH1	HH2
36175E-11	0.0E0	0.0E0	0.0E0	0.0E0	.26496E8	0.0E0

HH3	HH4	HH5	RN	XL	CONEAN
0.0E0	0.0E0	0.0E0	.05E0	.0864E0	.1367[illegible]0

INDP	INDR	INDLR	INDLSR	INDS5	INDS6	INDS7
2	2	0	0	0	0	0

OGIVEH	OGIVEK	P(1)	P(2)	P(3)	P(4)	P(5)
0.0E0	0.0E0	0.0E0	43.840E0	-4.4213E0	0.0E0	0.0E0

P(6)	P(7)	P(8)	CC(1,1)	CC(2,1)	CC(3,1)	CC(4,1)
0.0E0	0.0E0	0.0E0	.22741E0	0.0E0	0.0E0	0.0E0

CC(5,1)	CC(1,2)	CC(2,2)	CC(3,2)	CC(4,2)	CC(5,2)	CC(1,3)
0.0E0	.67227E-3	0.0E0	0.0E0	0.0E0	0.0E0	.76457E0

CC(2,3)	CC(3,3)	CC(4,3)	CC(5,3)	CC(1,4)	CC(2,4)	CC(3,4)
0.0E0	0.0E0	0.0E0	0.0E0	.14702E-8	0.0E0	0.0E0

CC(4,4)	CC(5,4)	CC(1,5)	CC(2,5)	CC(3,5)	CC(4,5)	CC(5,5)
0.0E0	0.0E0	.73356E-2	0.0E0	0.0E0	0.0E0	0.0E0

CC(1,6)	CC(2,6)	CC(3,6)	CC(4,6)	CC(5,6)	HH1	HH2
36175E-11	0.0E0	0.0E0	0.0E0	0.0E0	.26496E8	0.0E0

HH3	HH4	HH5	RN	XL	CONEAN
0.0E0	0.0E0	0.0E0	.05E0	.2877E0	.136718E0

INDP	INDR	INDLR	INDLSR	INDS5	INDS6	INDS7
2	2	1	1	0	0	0

OGIVEH	OGIVEK	P(1)	P(2)	P(3)	P(4)	P(5)
0.0E0	0.0E0	0.0E0	19.228E0	-.13784E0	0.0E0	0.0E0

P(6)	P(7)	P(8)	CC(1,1)	CC(2,1)	CC(3,1)	CC(4,1)
0.0E0	0.0E0	0.0E0	.22741E0	0.0E0	0.0E0	0.0E0

CC(5,1)	CC(1,2)	CC(2,2)	CC(3,2)	CC(4,2)	CC(5,2)	CC(1,3)
0.0E0	.67227E-3	0.0E0	0.0E0	0.0E0	0.0E0	.76457E0

CC(2,3)	CC(3,3)	CC(4,3)	CC(5,3)	CC(1,4)	CC(2,4)	CC(3,4)
0.0E0	0.0E0	0.0E0	0.0E0	.14702E-8	0.0E0	0.0E0

CC(4,4)	CC(5,4)	CC(1,5)	CC(2,5)	CC(3,5)	CC(4,5)	CC(5,5)
0.0E0	0.0E0	.73356E-2	0.0E0	0.0E0	0.0E0	0.0E0

CC(1,6)	CC(2,6)	CC(3,6)	CC(4,6)	CC(5,6)	HH1	HH2
36175E-11	0.0E0	0.0E0	0.0E0	0.0E0	.26496E8	0.0E0

HH3	HH4	HH5	RN	XL	CONEAN
0.0E0	0.0E0	0.0E0	.05E0	1.5415E0	.136718E0

APPENDIX V

SAMPLE OUTPUT

GENERAL APPLIED SCIENCE LABS

FINITE DIFFERENCE SOLUTION OF CHEMICALLY REACTING AIR BOUNDARY LAYERS

FIRING RANGE BLUNTED CONE

NON UNITY FLOW PARAMETERS

LAMINAR CHEMISTRY RUN

FLIGHT CONDITIONS AND FREE STREAM PROPERTIES

ALT (K FT)	CP (FT/SEC) SQ/K	STAT ENTH (FT/SEC) SQ	GAMMA	PRESS (LB/SQ FT)	DENSITY (SLUGS/CU FT)	TEMP (DEG K)	VEL (FT/SEC)
150	4.32000E-01	1.20096E 02	1.40000E 00	3.05970E 09	3.56420E-06	2.78000E 02	1.52000E 04

C(O2)	C(O)	C(N2)	C(N)	C(NO)	C(NO+)	C(E-)
2.32000E-01	0.	7.68000E-01	0.	0.	0.	0.

SHOCK CONDITIONS

STAG DENSITY (SLUGS/CU FT)	NSR
4.13790E-05	4

SHOCK REGION NO 1

TYPE	SHANGL (RAD)	STANDOFF DIST (FT)	GEOM COEF ASR	GEOM COEF BSR	GEOM COEF CSR	LIMITS Z1R (FT)	LIMITS Z2R (FT)
PARABOLIC	0.	0.	0.	5.37750E 00	0.	1.03600E-03	1.38801E-02

SHOCK REGION NO 2

TYPE	SHANGL (RAD)	STANDOFF DIST (FT)	GEOM COEF ASR	GEOM COEF BSR	GEOM COEF CSR	LIMITS Z1R (FT)	LIMITS Z2R (FT)
PARABOLIC	0.	0.	6.09620E-04	1.30670E 01	8.16800E-03	4.26630E-02	6.49117E-02

SHOCK REGION NO 3

TYPE	SHANGL (RAD)	STANDOFF DIST (FT)	GEOM COEF ASR	GEOM COEF BSR	GEOM COEF CSR	LIMITS Z1R (FT)	LIMITS Z2R (FT)
PARABOLIC	0.	0.	9.61180E-03	1.66250E 01	2.03120E-02	3.90380E-01	1.68758E-01

SHOCK REGION NO 4

TYPE	SHANGL (RAD)	STANDOFF DIST (FT)	GEOM COEF ASR	GEOM COEF BSR	GEOM COEF CSR	LIMITS Z1R (FT)	LIMITS Z2R (FT)

PROBLEM TYPE
SHOCK CROSSING STREAMLINE CALC INITIAL PROFILES INPUT

NO GRID PTS	NO SPECIES	NOSE RADIUS (FT)	OVERALL ZETA (FT)	NPSI	JINPUT	RESTAR
18	7	5.00000E-02	1.50000E 00	1	20	1.00000E 00

XS (FT)	Z1S (FT)	Z2S (FT)	DELTAX (FT)
5.19000E-02	2.80600E-02	4.13050E-02	1.00000E-09

A1L	A1T	A2	A3L	A3T	A4L	A4T
1.00000E 00	0.	1.00000E 00	1.00000E 00	0.	1.00000E 00	0.

A5L	A5T	STEP SIZE TOLERANCES		STAB. FACTOR
1.00000E 00	0.	5.00000E-03	7.50000E-02	0.

U LOLIM (FT/SEC)	U	THICKNESS CRITERIA C(O2)	C(O)	C(N2)	C(N)	C(NO)	H
1.00000E 02	9.90000E-01	9.90000E-01	9.90000E-01	9.90000E-01	9.90000E-01	9.90000E-01	9.90000E-01

EPSI	EPSI U	EPSI C(O2)	EPSI C(O)	EPSI C(N2)	EPSI C(N)	EPSI C(NO)	EPSI H	EPSI T
1.00000E 00	5.00000E-04	0.	0.	0.	0.	0.	10.00000E-05	10.00000E-03

LEWIS NO LAMINAR	LEWIS NO TURBULENT	PRANDTL NO LAMINAR	PRANDTL NO TURBULENT	SCHMIDT NO LAMINAR	SCHMIDT NO TURBULENT
1.40000E 00	1.40000E 00	7.00000E-01	7.00000E-01	5.00000E-01	5.00000E-01

DIFFUSION COEF RATIOS LAMINAR

O2	O	N2	N	NO	NO+	E-
1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00

DIFFUSION COEF RATIOS TURBULENT

O2	O	N2	N	NO	NO+	E-
1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00

TESTRA	AB1T	AB2T	AB3T	AB4T	AB5T	AB6T	AB7T
2.00000E-01	0.	0.	0.	0.	0.	0.	0.

	BB1T	BB2T	BB3T	BB4T	BB5T	BB6T	BB7T
	0.	0.	0.	0.	0.	0.	0.

FK	FA	FB	FC	FEOA	FEOB	FEOC
4.00000E-01	4.00000E-01	0.	0.	0.	0.	0.

SUBREGION VALUES AND WALL PARAMETERS

PRES TYPE		PRES COEF				
2	0.	5.93330E 02	-4.10150E 02	0.	0.	0.	0.	0.

GEOM SUBR	OGIVEH (FT)	OGIVEK (FT)	RN (FT)	XL (FT)	CONEAN (RAD)	PRINTOUT INT
1	5.34000E-02	0.	5.00000E-02	6.17500E-02	0.	5

CWALL COEF

O2	O	N2	N	NO	NO+	E-	H WALL COEF
2.27410E-01	6.72270E-04	7.64570E-01	1.47020E-09	7.33560E-03	3.61750E-12	0.	2.64960E 07
0.	0.	0.	0.	0.	0.	0.	0.

0. 0. 0. 0. 0. 0. 0. 0.

INITIAL PROFILES

Y (FT)	C(O2)	C(O)	C(N2)	C(N)	C(NO)	C(NO+)	C(E-)	H (FT/SEC)SQ	U (FT/SEC)
0.	2.27410E-01	6.72270E-04	7.64582E-01	1.47020E-09	7.33560E-03	3.61750E-12	6.61368E-17	2.64900E 07	0.
5.27160E-05	2.21700E-01	3.34760E-03	7.61929E-01	3.09770E-08	1.30230E-02	9.33130E-11	1.70599E-15	3.12760E 07	4.25100E 02
1.11280E-04	2.11830E-01	1.00070E-02	7.59113E-01	2.53660E-07	1.90500E-02	8.78540E-10	1.60619E-14	3.60580E 07	8.50370E 02
2.43040E-04	1.79820E-01	3.68190E-02	7.54558E-01	3.41050E-06	2.88000E-02	1.37900E-08	2.52115E-13	4.56200E 07	1.70070E 03
3.92160E-04	1.42970E-01	7.10430E-02	7.52244E-01	1.44240E-05	3.37280E-02	6.16810E-08	1.12768E-12	5.51820E 07	2.55110E 03
5.58120E-04	1.11500E-01	1.01700E-01	7.51525E-01	3.53600E-05	3.52390E-02	1.52670E-07	2.79118E-12	6.47440E 07	3.40140E 03
7.43350E-04	8.53820E-02	1.27980E-01	7.51613E-01	6.92280E-05	3.49550E-02	2.95240E-07	5.39771E-12	7.43060E 07	4.25180E 03
9.53880E-04	6.26160E-02	1.51520E-01	7.52248E-01	1.26140E-04	3.34890E-02	5.23050E-07	9.56264E-12	8.38680E 07	5.10220E 03
1.20150E-03	4.35670E-02	1.71850E-01	7.53256E-01	2.23430E-04	3.11030E-02	8.87710E-07	1.62295E-11	9.34280E 07	5.95250E 03
1.51230E-03	2.94100E-02	1.87530E-01	7.54434E-01	3.79770E-04	2.82450E-02	1.43120E-06	2.61659E-11	1.02985E 08	6.80290E 03
1.96430E-03	2.00970E-02	1.98310E-01	7.55510E-01	6.02740E-04	2.54780E-02	2.15020E-06	3.93109E-11	1.12551E 08	7.65330E 03
2.31680E-03	1.69080E-02	2.02150E-01	7.55942E-01	7.34940E-04	2.42620E-02	2.55540E-06	4.67190E-11	1.17333E 08	8.07850E 03
2.43690E-03	1.49040E-02	2.04620E-01	7.56231E-01	8.46540E-04	2.33960E-02	2.88820E-06	5.28034E-11	1.21160E 08	8.41860E 03
2.52700E-03	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	1.22112E 08	8.50370E 03
2.61710E-03	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	1.22113E 08	8.50370E 03
2.70720E-03	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	1.22114E 08	8.50370E 03
2.79730E-03	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	1.22115E 08	8.50370E 03
2.88740E-03	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	1.22116E 08	8.50370E 03
2.97750E-03	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	1.22116E 08	8.50370E 03
3.06730E-03	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	1.22116E 08	8.50370E 03

1	0.
2	1.02230E-08
3	4.21912E-08
4	1.71171E-07
5	3.95443E-07
6	7.22983E-07
7	1.16515E-06
8	1.74654E-06
9	2.51731E-06
10	3.58718E-06
11	5.28204E-06
12	6.68178E-06
13	7.17443E-06
14	7.55062E-06
15	7.92814E-06
16	8.30566E-06
17	8.68317E-06
18	9.06067E-06
19	0.
20	0.

STATION VALUES 0 0 9 0 5

X (FT)	DELTA X (FT)	ZETA 1 (FT)	RAO BODY (FT)	BL MASS FLOW (LB SEC/FT)	STREAMTUBE RAD (FT)	WALL PRES (LB/SQ FT)	RETHETA
5.1900001E-0?	1.0000000E-09	0.	0.	5.93238E-05	1.86697E-02	1.67594E 02	0.

DELTA U (FT)	DELTA V (FT)	DELTA C(O2) (FT)	DELTA C(O) (FT)	DELTA C(N2) (FT)	DELTA C(N) (FT)	DELTA C(NO) (FT)	DELTA C(NO+) (FT)	DELTA C(E-) (FT)
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03

REX	REM	DELTA STAR (FT)	THETA (FT)	NU/SQRT (REX)	NU/SQRT (REM)	C SUB F
0.	0.	7.61037E-04	4.66866E-04	-0.	-0.	0.

K	C(O2)	C(O)	C(N2)	C(N)	C(NO)	C(NO+)	C(E-)	CSUM
1	2.27410E-01	6.72270E-04	7.64582E-01	1.47020E-09	7.33560E-03	3.61750E-12	6.61368E-17	10.00000E-01
2	1.29755E-01	8.39162E-02	7.51943E-01	2.32153E-05	3.43625E-02	9.98883E-08	1.82620E-12	10.00000E-01
3	9.12410E-02	1.22085E-01	7.51594E-01	6.16305E-05	3.50187E-02	2.63258E-07	4.81300E-12	10.00000E-01
4	6.83956E-02	1.45544E-01	7.52087E-01	1.11692E-04	3.38612E-02	4.65216E-07	8.50529E-12	10.00000E-01
5	5.30915E-02	1.61685E-01	7.52752E-01	1.74785E-04	3.22960E-02	7.05380E-07	1.28961E-11	10.00000E-01
6	4.16140E-02	1.74013E-01	7.53418E-01	2.44998E-04	3.07087E-02	9.62688E-07	1.76003E-11	10.00000E-01
7	3.45613E-02	1.81824E-01	7.54005E-01	3.22882E-04	2.92849E-02	1.23344E-06	2.25503E-11	10.00000E-01
8	2.86205E-02	1.88444E-01	7.54525E-01	3.98673E-04	2.80104E-02	1.49215E-06	2.72803E-11	10.00000E-01
9	2.56918E-02	1.91834E-01	7.54863E-01	4.68790E-04	2.71403E-02	1.71826E-06	3.14140E-11	10.00000E-01
10	2.27632E-02	1.95224E-01	7.55202E-01	5.38907E-04	2.62702E-02	1.94436E-06	3.55477E-11	10.00000E-01
11	1.99882E-02	1.98441E-01	7.55525E-01	6.07251E-04	2.54365E-02	2.16403E-06	3.95637E-11	10.00000E-01
12	1.87739E-02	1.99903E-01	7.55689E-01	6.57589E-04	2.49735E-02	2.31832E-06	4.23845E-11	10.00000E-01
13	1.75596E-02	2.01365E-01	7.55854E-01	7.07927E-04	2.45105E-02	2.47260E-06	4.52053E-11	10.00000E-01
14	1.59034E-02	2.03388E-01	7.56087E-01	7.90885E-04	2.38279E-02	2.72223E-06	4.97691E-11	10.00000E-01
15	1.45718E-02	2.05032E-01	7.56282E-01	8.68145E-04	2.32425E-02	2.95174E-06	5.39651E-11	10.00000E-01
16	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01
17	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01
18	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01
19	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01
20	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01

K	PSI (LB SEC/FT)	Y (FT)	U (FT/SEC)	T (DEG K)	SMALL H (FT/SEC) SQ	H (FT/SEC) SQ	RHO (SLUGS/CU FT)
1	0.	0.	0.	2.13739E 03	2.64960E 07	2.64960E 07	2.52367E-05
2	5.32981E-07	4.94177E-04	2.90815E 03	2.43659E 03	3.11856E 07	5.91972E 07	1.62111E-05
3	1.06596E-06	7.37640E-04	4.06103E 03	2.66925E 03	3.56964E 07	7.21610E 07	1.49018E-05
4	1.59894E-06	9.37584E-04	4.88631E 03	2.92658E 03	4.41738E 07	8.14405E 07	1.41470E-05
5	2.13192E-06	1.11638E-03	5.52735E 03	3.04724E 03	5.19279E 07	8.86480E 07	1.36572E-05
6	2.66490E-06	1.28189E-03	6.06982E 03	3.16703E 03	5.89592E 07	9.47464E 07	1.32801E-05
7	3.19788E-06	1.43829E-03	6.49346E 03	3.29234E 03	6.52671E 07	9.95075E 07	1.30119E-05
8	3.73086E-06	1.58811E-03	6.87499E 03	3.40126E 03	7.08518E 07	1.03796E 08	1.27749E-05
9	4.26385E-06	1.73313E-03	7.14242E 03	3.49876E 03	7.57119E 07	1.06804E 08	1.26225E-05
10	4.79683E-06	1.87452E-03	7.40984E 03	3.60118E 03	7.98453E 07	1.09812E 08	1.24701E-05
11	5.32981E-06	2.01261E-03	7.66781E 03	3.71113E 03	8.32645E 07	1.12714E 08	1.23241E-05
12	5.86279E-06	2.14819E-03	7.82971E 03	3.76492E 03	8.47019E 07	1.14535E 08	1.22429E-05
13	6.39577E-06	2.28188E-03	7.99162E 03	3.80586E 03	8.57236E 07	1.16356E 08	1.21618E-05
14	6.92875E-06	2.41322E-03	8.24899E 03	3.81533E 03	8.59555E 07	1.19251E 08	1.20410E-05
15	7.46173E-06	2.54188E-03	8.48359E 03	3.81540E 03	8.59565E 07	1.21887E 08	1.19375E-05
16	7.99471E-06	2.66919E-03	8.50370E 03	3.81547E 03	8.59575E 07	1.22113E 08	1.19290E-05
17	8.52769E-06	2.79639E-03	8.50370E 03	3.81555E 03	8.59585E 07	1.22115E 08	1.19287E-05
18	9.06067E-06	2.92360E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05
19	9.59365E-06	3.05081E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05
20	1.01266E-05	3.17802E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05

K	ELECTRON DENS PART/CC	MU L (LB SEC/SQFT)	MU T (LB SEC/SQFT)	TAUM (LB/SQFT)
1	9.45480E 05	0.	0.	0.
2	1.67702E 10	0.	0.	0.
3	4.06286E 10	0.	0.	0.
4	6.81601E 10	0.	0.	0.
5	9.97687E 10	0.	0.	0.
6	1.32403E 11	0.	0.	0.
7	1.66215E 11	0.	0.	0.
8	1.97416E 11	0.	0.	0.
9	2.24618E 11	0.	0.	0.
10	2.51106E 11	0.	0.	0.
11	2.76203E 11	0.	0.	0.
12	2.93947E 11	0.	0.	0.
13	3.11431E 11	0.	0.	0.
14	3.39468E 11	0.	0.	0.
15	3.64925E 11	0.	0.	0.
16	3.67093E 11	0.	0.	0.
17	3.67084E 11	0.	0.	0.
18	3.67074E 11	0.	0.	0.
19	3.67074E 11	0.	0.	0.
20	3.67074E 11	0.	0.	0.

U 1/2	FH 1/2	RHO 1/2	T 1/2	V 1/2	SM H 1/2	TAUM 1/2	EDEN 1/2
2.07465E 03	2.64960E 07	2.52367E-05	2.13739E 03	0.	2.64960E 07	0.	9.45480E 05

C(I) 1/2						
2.27410E-01	6.72270E-04	7.64582E-01	1.47020E-09	7.33560E-03	3.61750E-12	6.61368E-17

STATION VALUES 5 3 3 5 5

X (FT)	DELTA X (FT)	ZETA 1 (FT)	RAD BODY (FT)	BL MASS FLOW (LB SEC/FT)	STREAMTUBE RAD (FT)	WALL PRES (LB/SQ FT)	RETHETA
5.1900058E-02	3.2000000E-08	2.7253924E-02	4.2619041E-02	5.91032E-05	1.86475E-02	1.67594E 02	2.51014E 01

DELTA U (FT)	DELTA V (FT)	DELTA C(O2) (FT)	DELTA C(O) (FT)	DELTA C(N2) (FT)	DELTA C(N) (FT)	DELTA C(NO) (FT)	DELTA C(NO+) (FT)	DELTA C(E-) (FT)
2.43340E-03	2.42097E-03	2.83787E-03	2.32559E-03	2.83787E-03	2.46460E-03	2.83787E-03	2.46247E-03	2.46247E-03

REX	REW	DELTA STAR (FT)	THETA (FT)	NU/SQRT (REX)	NU/SQRT (REW)	C SUB F
2.87921E 03	8.31842E 03	7.41979E-04	4.52473E-04	7.96174E-01	4.68407E-01	2.13448E-02

I	C(O2)	C(O)	C(N2)	C(N)	C(NO)	C(NO+)	C(E-)	CSUM
1	2.27410E-01	6.72270E-04	7.64570E-01	1.47020E-09	7.33560E-03	3.61750E-12	6.61368E-17	9.99988E-01
2	1.29756E-01	6.39162E-02	7.51943E-01	2.32167E-05	3.43619E-02	9.98940E-08	1.82631E-12	10.00000E-01
3	8.12417E-02	1.22084E-01	7.51594E-01	6.16322E-05	3.50186E-02	2.63264E-07	4.81311E-12	10.00000E-01
4	6.83961E-02	1.45543E-01	7.52087E-01	1.11694E-04	3.38611E-02	4.65222E-07	8.50540E-12	10.00000E-01
5	5.30918E-02	1.61685E-01	7.52752E-01	1.74786E-04	3.22960E-02	7.05384E-07	1.28961E-11	10.00000E-01
6	4.16144E-02	1.74013E-01	7.53418E-01	2.45000E-04	3.07087E-02	9.62691E-07	1.76004E-11	10.00000E-01
7	3.45614E-02	1.81824E-01	7.54005E-01	3.22883E-04	2.92850E-02	1.23344E-06	2.25503E-11	10.00000E-01
8	2.86208E-02	1.88444E-01	7.54525E-01	3.98673E-04	2.80105E-02	1.49215E-06	2.72802E-11	10.00000E-01
9	2.56918E-02	1.91834E-01	7.54863E-01	4.68790E-04	2.71403E-02	1.71826E-06	3.14140E-11	10.00000E-01
10	2.27632E-02	1.95224E-01	7.55202E-01	5.38907E-04	2.62702E-02	1.94436E-06	3.55477E-11	10.00000E-01
11	1.99884E-02	1.98441E-01	7.55525E-01	6.07249E-04	2.54366E-02	2.16402E-06	3.95636E-11	10.00000E-01
12	1.87739E-02	1.99903E-01	7.55689E-01	6.57589E-04	2.49735E-02	2.31832E-06	4.23845E-11	10.00000E-01
13	1.75596E-02	2.01365E-01	7.55854E-01	7.07932E-04	2.45104E-02	2.47262E-06	4.52055E-11	10.00000E-01
14	1.59034E-02	2.03388E-01	7.56087E-01	7.90885E-04	2.38279E-02	2.72223E-06	4.97691E-11	10.00000E-01
15	1.45720E-02	2.05032E-01	7.56282E-01	8.68136E-04	2.32426E-02	2.95171E-06	5.39645E-11	10.00000E-01
16	1.44690E-02	2.05160E-01	7.56298E-01	8.74829E-04	2.31950E-02	2.97140E-06	5.43244E-11	10.00000E-01
17	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01
18	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01
19	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01
20	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01

K	PSI (LB SEC/FT)	Y (FT)	U (FT/SEC)	T (DEG K)	SMALL H (FT/SEC) SQ	H (FT/SEC) SQ	RHO (SLUGS/CU FT)
1	0.	0.	0.	2.13742E 03	2.64960E 07	2.64960E 07	2.52367E-05
2	5.32981E-07	4.80655E-04	2.90815E 03	3.10402E 03	5.49666E 07	5.91971E 07	1.61649E-05
3	1.06596E-06	7.17187E-04	4.06103E 03	3.26662E 03	6.39150E 07	7.21609E 07	1.48736E-05
4	1.59894E-06	9.11330E-04	4.86630E 03	3.37858E 03	6.95025E 07	8.14404E 07	1.41207E-05
5	2.13192E-06	1.08497E-03	5.52735E 03	3.45653E 03	7.33722E 07	8.86479E 07	1.36262E-05
6	2.66490E-06	1.24565E-03	6.06981E 03	3.51598E 03	7.63251E 07	9.47464E 07	1.32663E-05
7	3.19788E-06	1.39745E-03	6.49346E 03	3.56992E 03	7.84249E 07	9.95075E 07	1.29860E-05
8	3.73086E-06	1.54285E-03	6.87499E 03	3.61251E 03	8.01632E 07	1.03796E 08	1.27666E-05
9	4.26385E-06	1.68358E-03	7.14242E 03	3.65128E 03	8.12971E 07	1.06804E 08	1.25973E-05
10	4.79683E-06	1.82086E-03	7.40984E 03	3.68494E 03	8.23595E 07	1.09812E 08	1.24491E-05
11	5.32981E-06	1.95482E-03	7.66760E 03	3.71318E 03	8.33165E 07	1.12714E 08	1.23232E-05
12	5.86279E-06	2.08625E-03	7.82971E 03	3.73501E 03	8.38828E 07	1.14535E 08	1.22370E-05
13	6.39577E-06	2.21587E-03	7.99162E 03	3.75498E 03	8.44229E 07	1.16356E 08	1.21578E-05
14	6.92875E-06	2.34320E-03	8.24899E 03	3.78647E 03	8.52285E 07	1.19251E 08	1.20373E-05
15	7.46173E-06	2.46792E-03	8.48358E 03	3.81314E 03	8.59014E 07	1.21887E 08	1.19373E-05
16	7.99471E-06	2.59130E-03	8.50370E 03	3.81542E 03	8.59567E 07	1.22113E 08	1.19290E-05
17	8.52769E-06	2.71458E-03	8.50370E 03	3.81552E 03	8.59581E 07	1.22115E 08	1.19287E-05
18	9.06067E-06	2.83787E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05
19	9.59365E-06	2.96116E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05
20	1.01266E-05	3.08444E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05

K	ELECTRON DENS PART/CC	MU L (LB SEC/SQFT)	MU T (LB SEC/SQFT)	TAUM (LB/SQFT)
1	9.45480E 05	1.33896E-06	0.	9.20574E 00
2	1.67234E 10	1.63861E-06	0.	9.09546E 00
3	4.05529E 10	1.68446E-06	0.	8.22637E 00
4	6.60345E 10	1.71432E-06	0.	7.25588E 00
5	9.95435E 10	1.73522E-06	0.	6.37958E 00
6	1.32266E 11	1.75100E-06	0.	5.89173E 00
7	1.65EE3E 11	1.76519E-06	0.	4.90899E 00
8	1.97287E 11	1.77632E-06	0.	4.64848E 00
9	2.24170E 11	1.7863EE-06	0.	3.38544E 00
10	2.50EE3E 11	1.7950EE-06	0.	3.48891E 00
11	2.76183E 11	1.80234E-06	0.	3.46430E 00
12	2.98E84E 11	1.80794E-06	0.	2.22375E 00
13	3.11331E 11	1.81304E-06	0.	2.26162E 00
14	3.39363E 11	1.82106E-06	0.	3.67329E 00
15	3.64951E 11	1.82783E-06	0.	3.43215E 00
16	3.67092E 11	1.82840E-06	0.	2.98029E-01
17	3.67083E 11	1.82843E-06	0.	1.08626E-05
18	3.67073E 11	1.82845E-06	0.	1.81041E-06
19	3.67073E 11	1.82845E-06	0.	0.
20	3.67073E 11	1.82845E-06	0.	0.

U 1/2	FH 1/2	RHO 1/2	T 1/2	Y 1/2	SP H 1/2	TAUM 1/2	EDEN 1/2
2.07465E 03	4.98308E 07	1.76318E-05	2.90841E 03	3.29699E-04	4.76785E 07	9.09546E 00	5.02542E 09

C(I) 1/2						
1.57656E-01	5.82456E-02	7.53913E-01	6.23856E-06	3.01770E-02	2.75210E-08	5.03152E-13

"STREAMLINE OUTPUT"

SHOCK ANGLE= 1.29687E 00 PRDS= 6.12958E 02 Z1A= 2.12017E-03 DIN2= 1.89198E-02 UDS= 4.81725E 03

XDD	ZDD	U	C(N)	C(NO)	C(NO+)	C(E-)	T	RHO	ME
2.32831E-19	2.12017E-03	4.81725E 03	7.37997E-20	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.49246E-19	2.12017E-03	4.81725E 03	1.10700E-19	6.97570E-35	0.	0.	8.23679E 03	2.39659E-05	0.
4.07454E-19	2.12017E-03	4.81725E 03	1.29149E-19	6.97570E-35	0.	0.	8.23679E 03	2.39659E-05	0.
4.65661E-19	2.12017E-03	4.81725E 03	1.47599E-19	6.97570E-35	0.	0.	8.23679E 03	2.39659E-05	0.
1.28057E-18	2.12017E-03	4.81725E 03	4.05898E-19	1.83112E-33	0.	0.	8.23679E 03	2.39659E-05	0.
2.44472E-18	2.12017E-03	4.81725E 03	7.74897E-19	7.20241E-33	0.	0.	8.23679E 03	2.39659E-05	0.
4.77303E-18	2.12017E-03	4.81725E 03	1.51289E-18	2.79900E-32	0.	0.	8.23679E 03	2.39659E-05	0.
1.03610E-17	2.12017E-03	4.81725E 03	3.28409E-18	1.32905E-31	0.	0.	8.23679E 03	2.39659E-05	0.
1.96742E-17	2.12017E-03	4.81725E 03	6.23607E-18	4.79457E-31	0.	0.	8.23679E 03	2.39659E-05	0.
3.83006E-17	2.12017E-03	4.81725E 03	1.21401E-17	1.81544E-30	0.	0.	8.23679E 03	2.39659E-05	0.
8.30041E-17	2.12017E-03	4.81725E 03	2.63096E-17	8.54337E-30	0.	0.	8.23679E 03	2.39659E-05	0.
1.57510E-16	2.12017E-03	4.81725E 03	4.99255E-17	3.07451E-29	0.	0.	8.23679E 03	2.39659E-05	0.
3.06522E-16	2.12017E-03	4.81725E 03	9.71574E-17	1.16293E-28	0.	0.	8.23679E 03	2.39659E-05	0.
6.64149E-16	2.12017E-03	4.81725E 03	2.10514E-16	5.46988E-28	0.	0.	8.23679E 03	2.39659E-05	0.
1.26020E-15	2.12017E-03	4.81725E 03	3.99441E-16	1.96808E-27	0.	0.	8.23679E 03	2.39659E-05	0.
2.45229E-15	2.12017E-03	4.81725E 03	7.77296E-16	7.44350E-27	0.	0.	8.23680E 03	2.39659E-05	0.
5.31331E-15	2.12017E-03	4.81725E 03	1.68415E-15	3.50088E-26	0.	0.	8.23680E 03	2.39659E-05	0.
1.00817E-14	2.12017E-03	4.81725E 03	3.19557E-15	1.25960E-25	0.	0.	8.23680E 03	2.39659E-05	0.
1.96184E-14	2.12017E-03	4.81725E 03	6.21842E-15	4.76390E-25	0.	0.	8.23680E 03	2.39659E-05	0.
4.25066E-14	2.12017E-03	4.81725E 03	1.34733E-14	2.24058E-24	0.	0.	8.23680E 03	2.39659E-05	0.
8.06535E-14	2.12017E-03	4.81725E 03	2.55647E-14	8.06148E-24	0.	0.	8.23680E 03	2.39659E-05	0.
1.56948E-13	2.12017E-03	4.81725E 03	4.97475E-14	3.04891E-23	0.	0.	8.23680E 03	2.39659E-05	0.
3.40053E-13	2.12017E-03	4.81725E 03	1.07786E-13	1.43398E-22	0.	0.	8.23680E 03	2.39659E-05	0.
6.45229E-13	2.12017E-03	4.81725E 03	2.04518E-13	5.15936E-22	0.	0.	8.23680E 03	2.39659E-05	0.
1.25558E-12	2.12017E-03	4.81725E 03	3.97981E-13	1.95131E-21	0.	0.	8.23680E 03	2.39659E-05	0.
2.72042E-12	2.12017E-03	4.81725E 03	8.62294E-13	9.17747E-21	0.	0.	8.23680E 03	2.39659E-05	0.
9.06808E-12	2.12017E-03	4.81725E 03	2.87432E-12	1.03320E-19	6.23059E-33	0.	8.23680E 03	2.39659E-05	0.
1.78571E-11	2.12017E-03	4.81725E 03	5.66020E-12	4.01703E-19	4.95563E-32	0.	8.23681E 03	2.39659E-05	0.
3.54353E-11	2.12017E-03	4.81725E 03	1.12320E-11	1.58261E-18	3.89122E-31	0.	8.23681E 03	2.39659E-05	0.
7.05915E-11	2.12017E-03	4.81725E 03	2.23756E-11	6.28101E-18	3.07771E-30	0.	8.23681E 03	2.39659E-05	0.
1.40904E-10	2.12017E-03	4.81725E 03	4.46628E-11	2.50242E-17	2.44752E-29	6.92053E-35	8.23681E 03	2.39659E-05	9.39529E-13
2.97154E-10	2.12017E-03	4.81725E 03	9.41900E-11	1.11374E-16	2.29987E-28	3.82647E-33	8.23681E 03	2.39659E-05	5.19480E-11
5.47154E-10	2.12017E-03	4.81725E 03	1.73434E-10	3.77335E-16	1.43248E-27	2.58111E-32	8.23681E 03	2.39659E-05	3.50410E-10
1.10965E-09	2.12017E-03	4.81725E 03	3.51732E-10	1.55145E-15	1.19446E-26	2.17999E-31	8.23681E 03	2.39659E-05	2.95954E-09
2.23465E-09	2.12017E-03	4.81725E 03	7.08330E-10	6.29237E-15	9.75812E-26	1.78365E-30	8.23681E 03	2.39659E-05	2.42147E-08
4.48465E-09	2.12017E-03	4.81725E 03	1.42153E-09	2.53449E-14	7.88877E-25	1.44222E-29	8.23681E 03	2.39659E-05	1.95796E-07
8.98465E-09	2.12017E-03	4.81725E 03	2.84793E-09	1.01733E-13	6.34415E-24	1.15986E-28	8.23681E 03	2.39659E-05	1.57462E-06
1.79846E-08	2.12018E-03	4.81725E 03	5.70075E-09	4.07640E-13	5.08863E-23	9.30325E-28	8.23681E 03	2.39659E-05	1.26301E-05
3.59846E-08	2.12019E-03	4.81725E 03	1.14065E-08	1.63198E-12	4.07624E-22	7.45237E-27	8.23681E 03	2.39659E-05	1.01173E-04
7.19846E-08	2.12022E-03	4.81725E 03	2.28181E-08	6.53076E-12	3.26314E-21	5.96583E-26	8.23680E 03	2.39659E-05	8.09918E-04
1.43985E-07	2.12027E-03	4.81726E 03	4.56424E-08	2.61286E-11	2.61139E-20	4.77426E-25	8.23679E 03	2.39659E-05	6.48151E-03
2.87985E-07	2.12038E-03	4.81727E 03	9.12944E-08	1.04525E-10	2.08948E-19	3.82008E-24	8.23675E 03	2.39659E-05	5.18611E-02
5.75985E-07	2.12059E-03	4.81731E 03	1.82613E-07	4.18114E-10	1.67175E-18	3.05637E-23	8.23668E 03	2.39658E-05	4.14931E-01
1.15198E-06	2.12101E-03	4.81737E 03	3.65305E-07	1.67243E-09	1.33751E-17	2.44529E-22	8.23654E 03	2.39658E-05	3.31970E 00
2.30398E-06	2.12185E-03	4.81750E 03	7.30912E-07	6.68925E-09	1.07011E-16	1.95642E-21	8.23625E 03	2.39656E-05	2.65599E 01
4.60798E-06	2.12352E-03	4.81775E 03	1.46302E-06	2.67526E-08	8.56216E-16	1.56537E-20	8.23567E 03	2.39653E-05	2.12509E 02
9.21598E-06	2.12688E-03	4.81826E 03	2.93076E-06	1.06974E-07	6.85168E-15	1.25266E-19	8.23452E 03	2.39648E-05	1.70052E 03
1.84320E-05	2.13360E-03	4.81928E 03	5.88018E-06	4.27597E-07	5.48428E-14	1.00266E-18	8.23222E 03	2.39636E-05	1.36108E 04
3.68640E-05	2.14704E-03	4.82133E 03	1.18334E-05	1.70797E-06	4.39170E-13	8.02910E-18	8.22763E 03	2.39614E-05	1.08982E 05
7.37280E-05	2.17392E-03	4.82541E 03	2.39467E-05	6.81200E-06	3.51094E-12	6.43348E-17	8.21847E 03	2.39568E-05	8.73075E 05
1.47456E-04	2.22768E-03	4.83358E 03	4.89197E-05	2.70816E-05	2.82035E-11	5.15630E-16	8.20028E 03	2.39476E-05	6.99484E 06
2.94912E-04	2.33520E-03	4.84988E 03	1.01278E-04	1.06893E-04	2.25421E-10	4.12125E-15	8.16440E 03	2.39291E-05	5.58640E 07
5.57056E-04	2.55635E-03	4.87876E 03	1.99472E-04	3.71115E-04	1.49576E-09	2.73462E-14	8.10272E 03	2.38946E-05	3.70147E 08
1.08134E-03	2.90864E-03	4.93614E 03	4.01841E-04	1.31493E-03	1.03207E-08	1.88688E-13	7.98549E 03	2.38210E-05	2.54621E 09
1.99885E-03	3.57766E-03	5.03548E 03	7.38032E-04	3.98423E-03	5.61643E-08	1.02682E-12	7.80043E 03	2.36759E-05	1.37714E 10
3.30957E-03	4.53340E-03	5.17537E 03	1.14503E-03	9.12567E-03	1.98865E-07	3.63574E-12	7.57720E 03	2.34170E-05	4.82280E 10
5.40672E-03	6.08258E-03	5.39566E 03	1.63219E-03	1.84331E-02	5.82712E-07	1.06534E-11	7.28960E 03	2.28983E-05	1.38187E 11
8.55245E-03	8.35634E-03	5.72225E 03	2.09343E-03	3.15757E-02	1.33699E-06	2.44435E-11	6.96588E 03	2.19130E-05	3.03418E 11